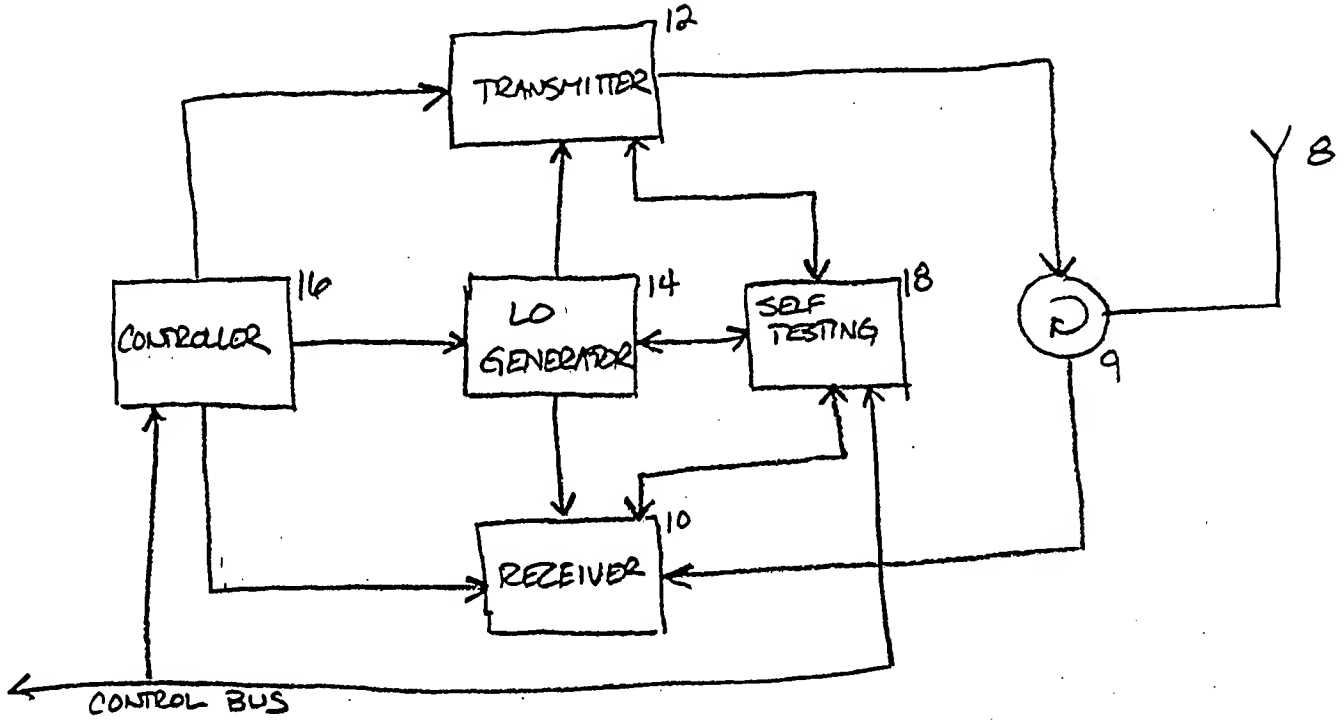

12
TRANSMITTER
8
16
CONTROLLER
14
LO GENERATOR
18
SELF TESTING
9
10
RECEIVER
CONTROL BUS

FIG. 1

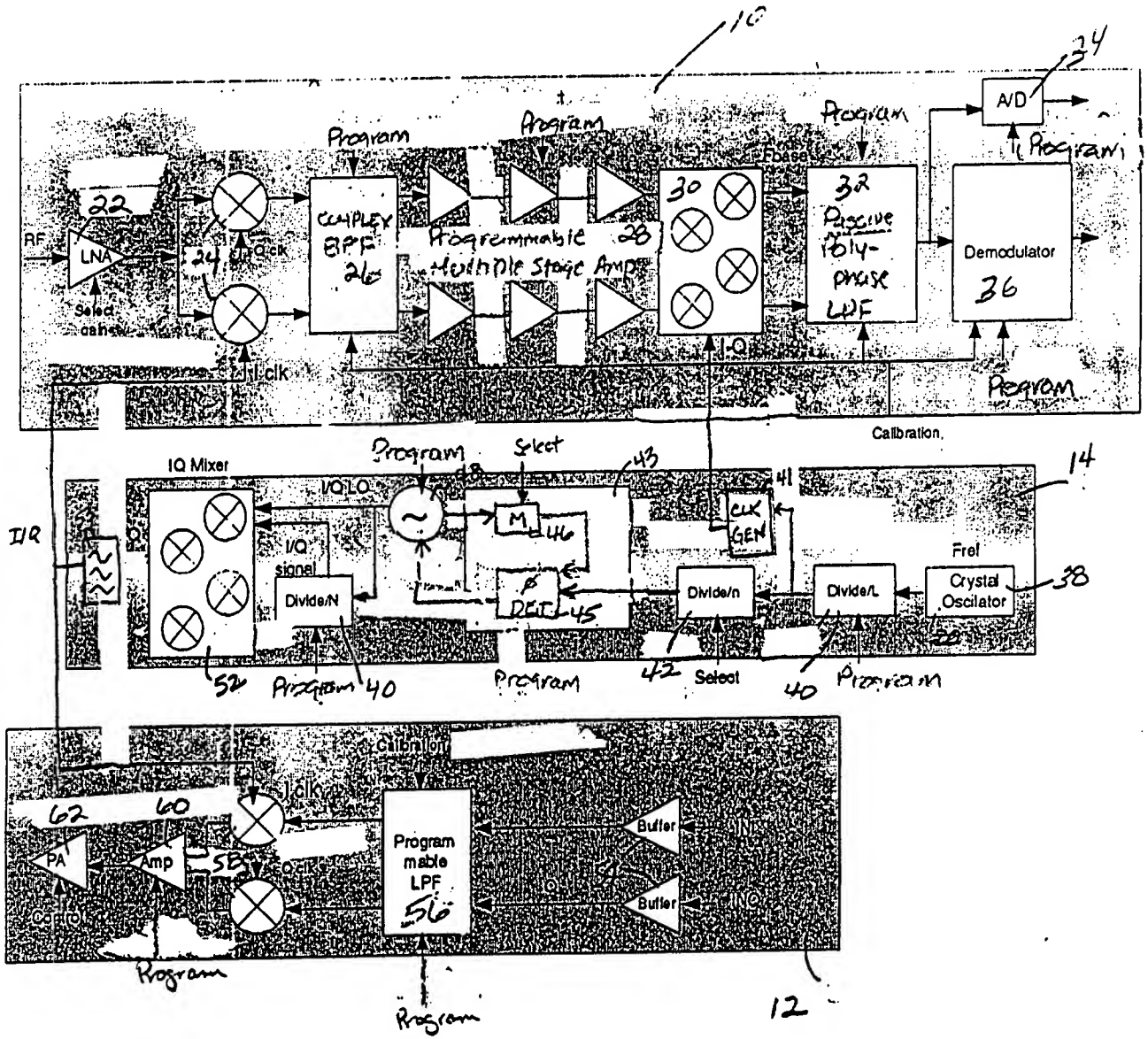


FIG. 2

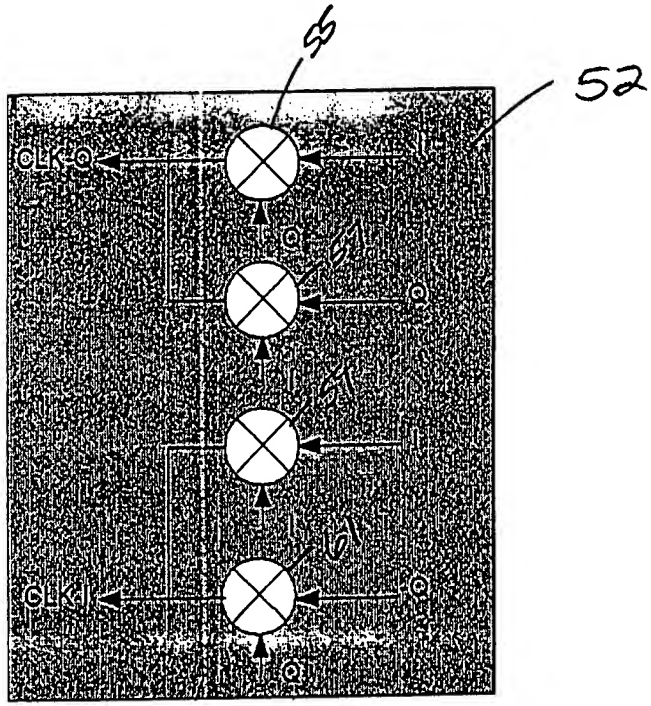


FIG. 3

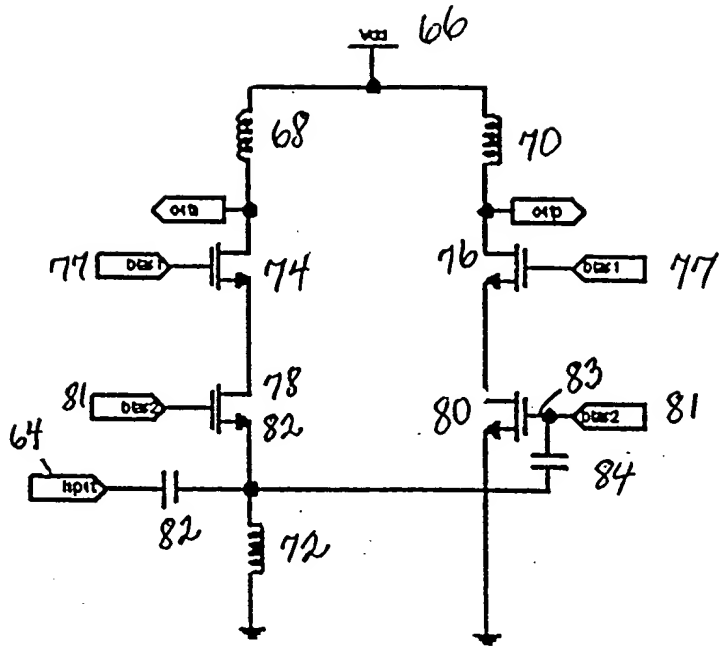

vdd
66
68
70
outb
outp
77
bbar
74
76
bbar1
77
81
bbar2
78
82
83
80
bbar2
81
64
bpch
82
84
82
72

FIG. 4

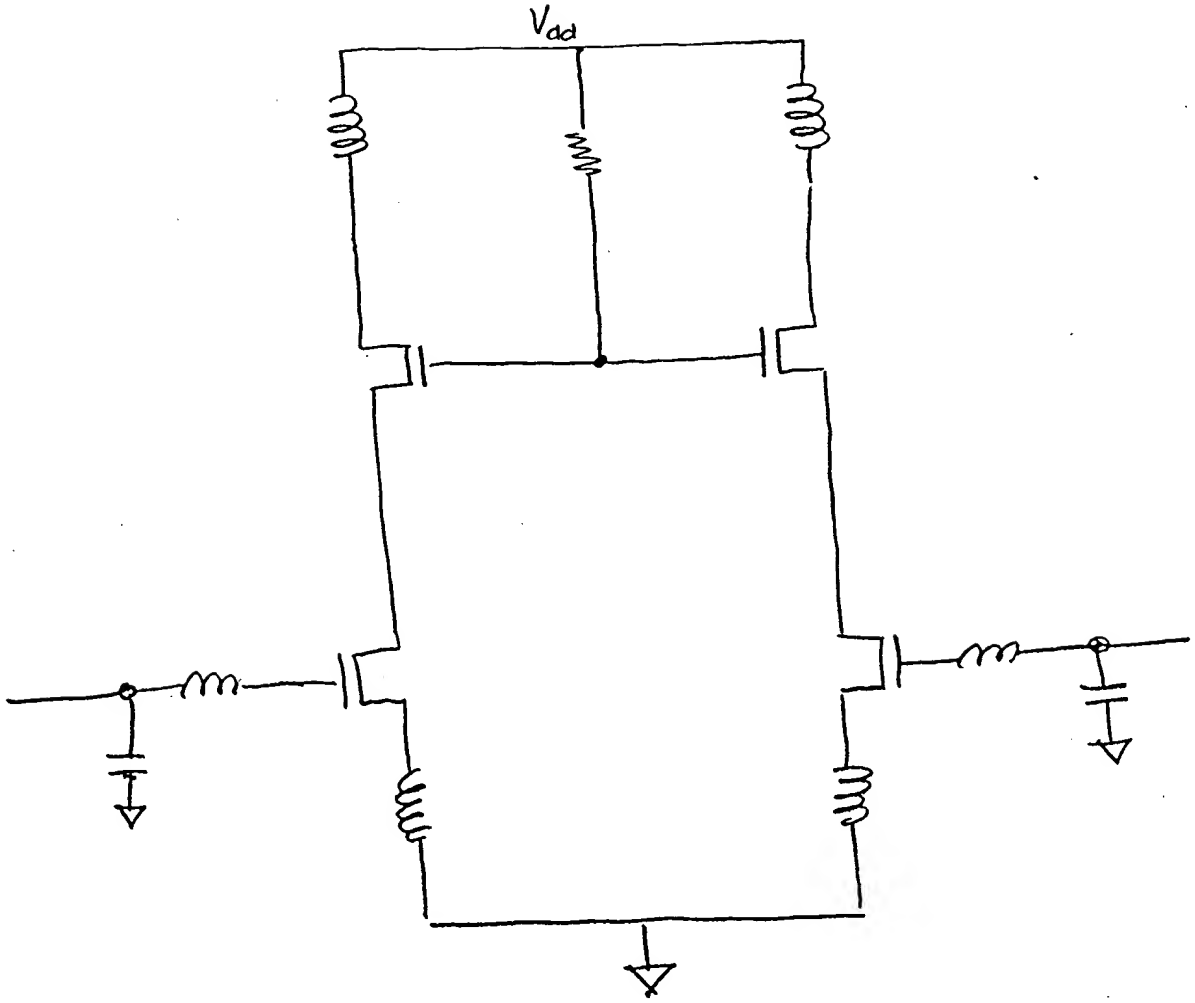


FIG. 4 (a)

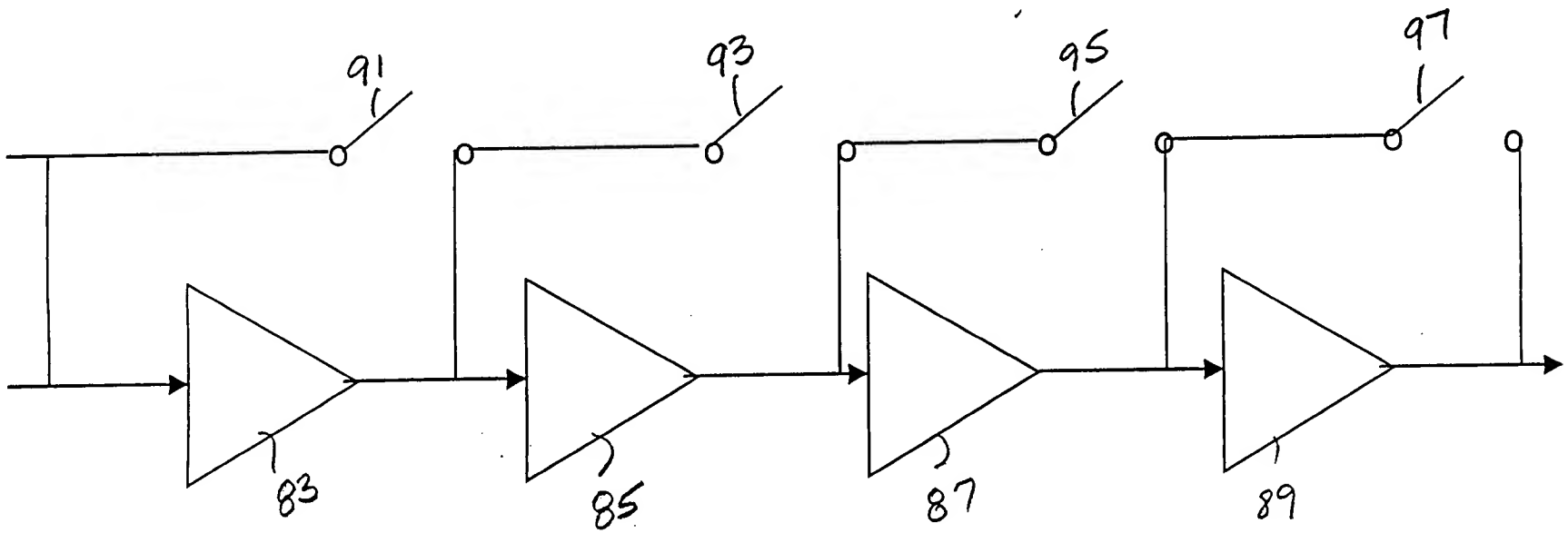


FIG. 5

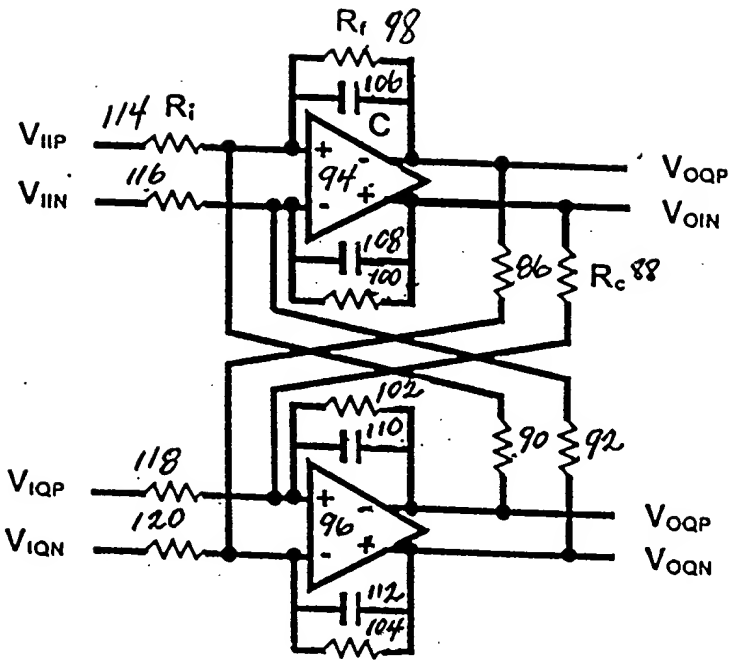

Rf 98
106
C
114 Ri
VIIP
116
VIIN
94
108
100
86
Rc 88
VOQP
VOIN
102
110
90
92
118
VIQP
120
VIQN
96
112
104
VOQP
VOQN

FIG. 6

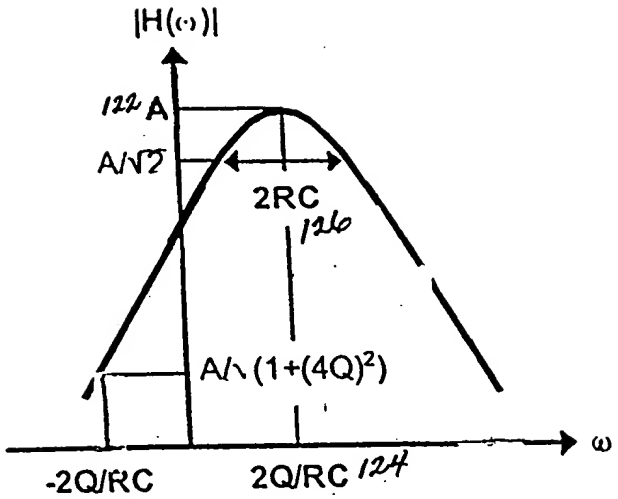


FIG. 7

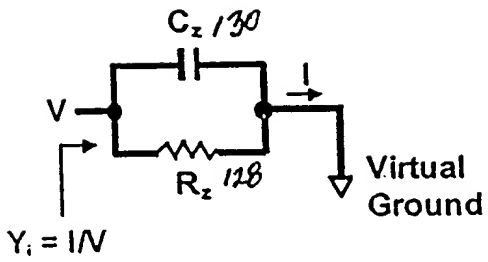


FIG. 8

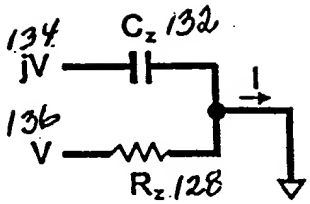


FIG. 9

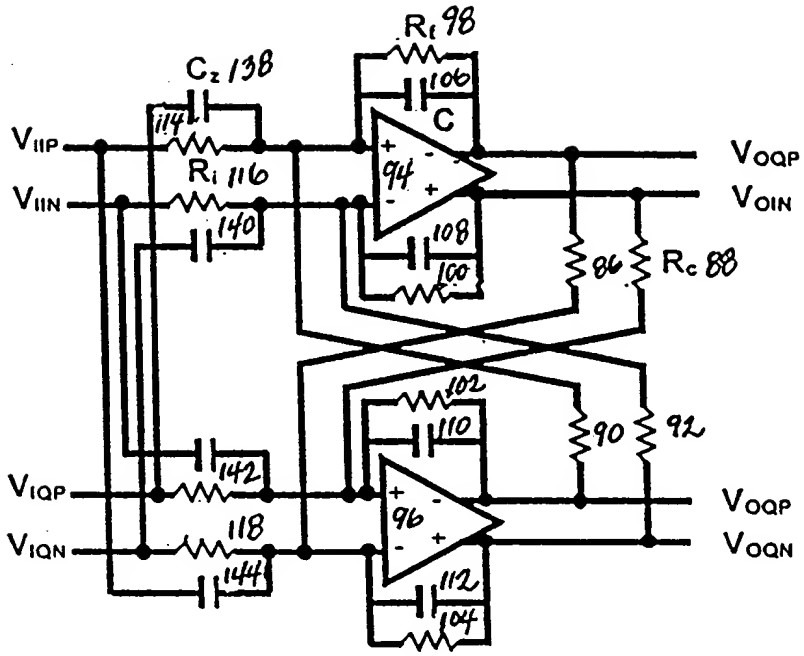

R_f 98
C_z 138
106
C
114
V_{IIP}
R_i 116
94
V_{OQP}
V_{IIN}
V_{OIN}
140
108
100
86
R_c 88
102
110
90
92
142
V_{IQP}
96
V_{OQP}
118
V_{IQN}
V_{OQN}
144
112
104

FIG. 10

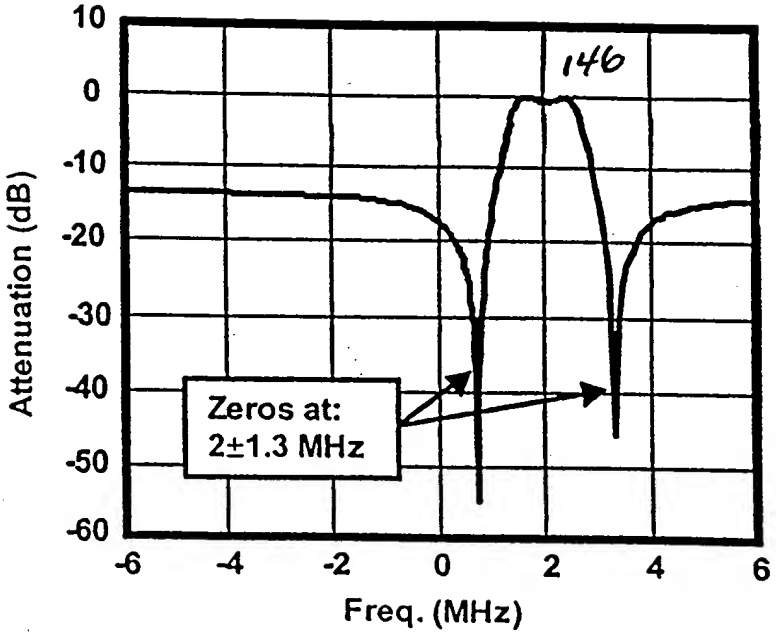

10
0
-10
-20
-30
-40
-50
-60
Attenuation (dB)
146
Zeros at:
2±1.3 MHz
-6
-4
-2
0
2
4
6
Freq. (MHz)

FIG. 11

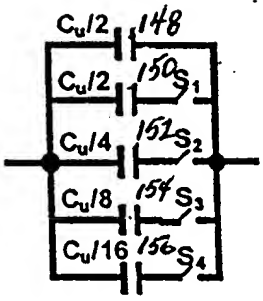


FIG. 12(a)

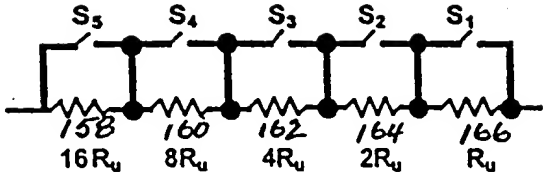


FIG. 12(b)

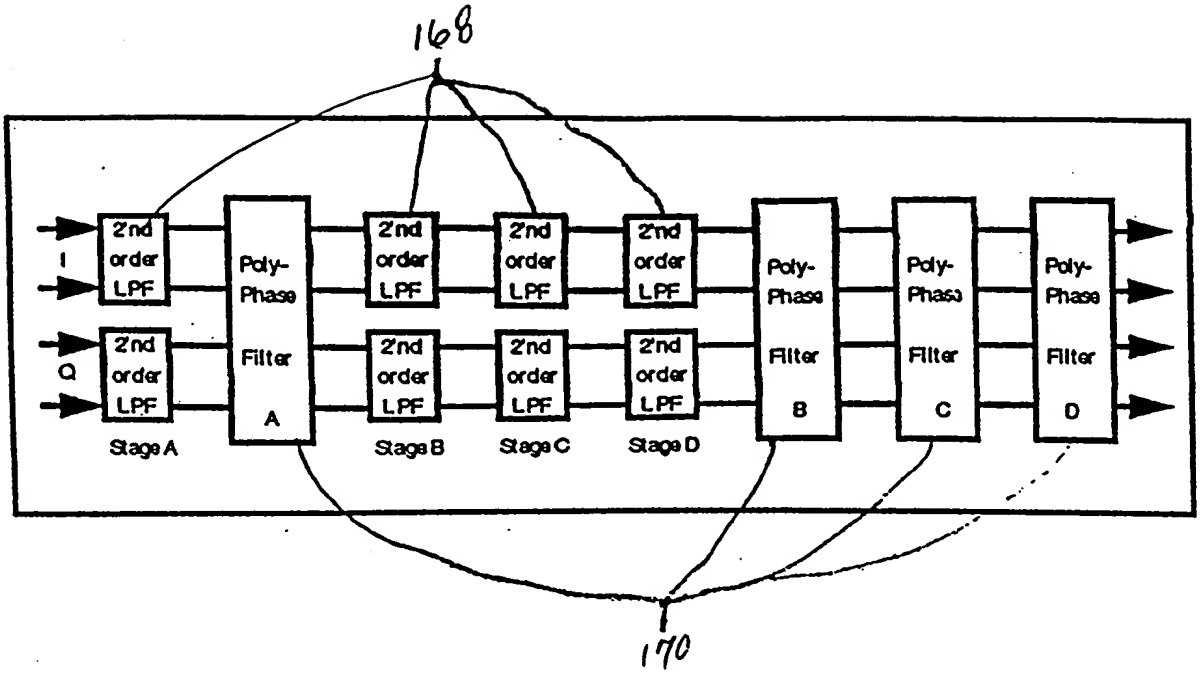

168
I
Q
2nd order LPF
Poly-Phase Filter A
Poly-Phase Filter B
Poly-Phase Filter C
Poly-Phase Filter D
Stage A
Stage B
Stage C
Stage D
170

FIG. 13

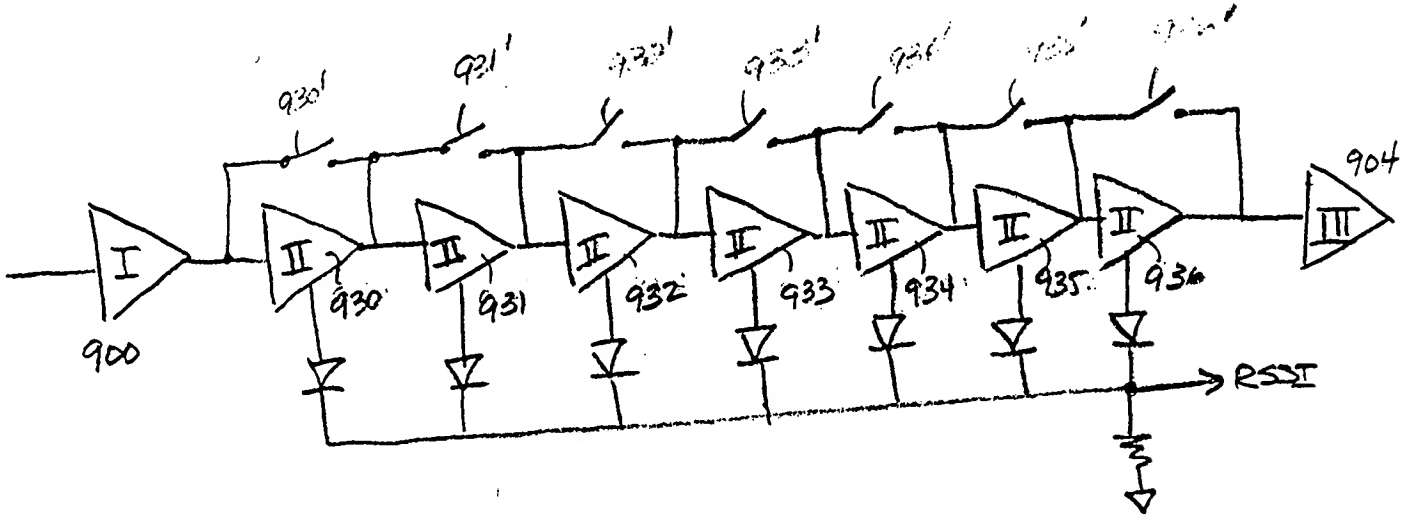


FIG. 14

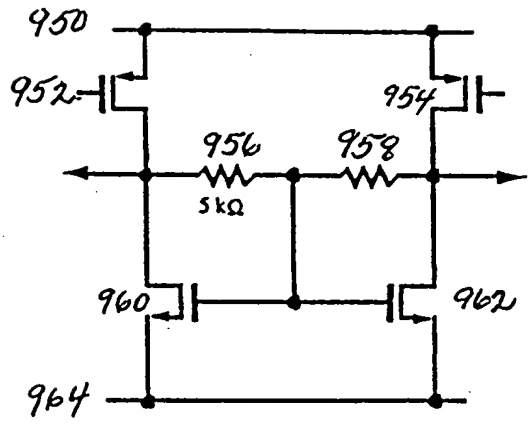


FIG. 15

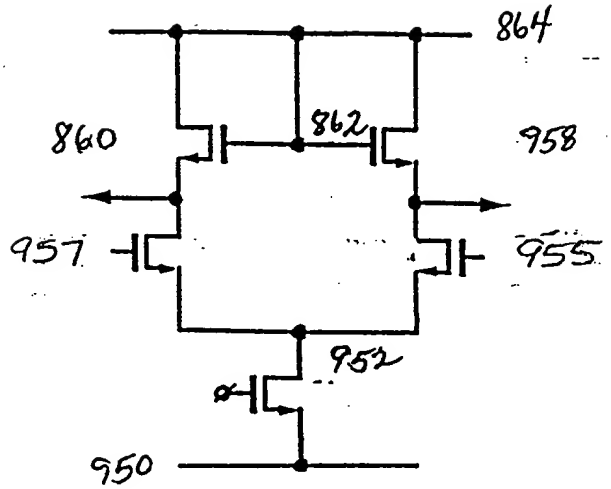


FIG. 16(a)

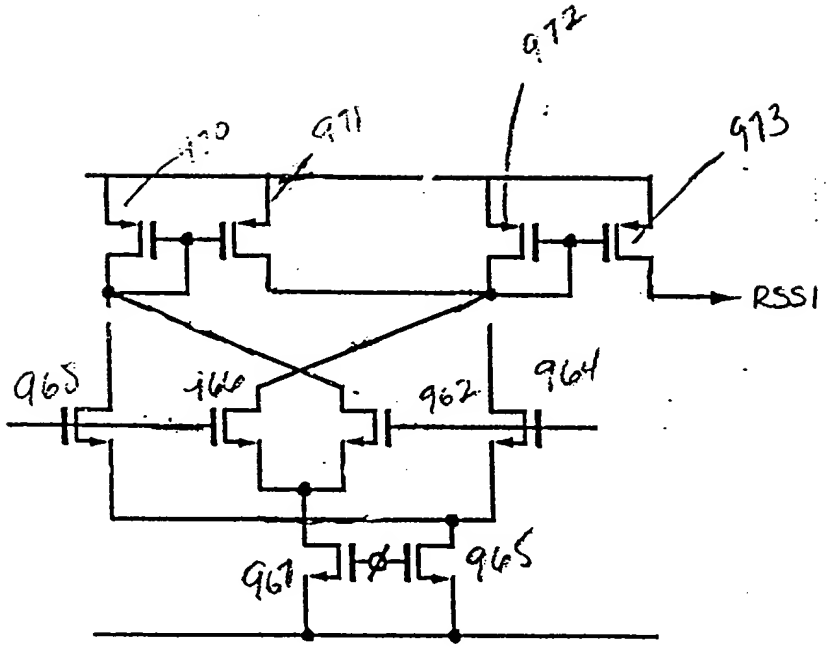


FIG. 16(b)

FIG. 17(a)

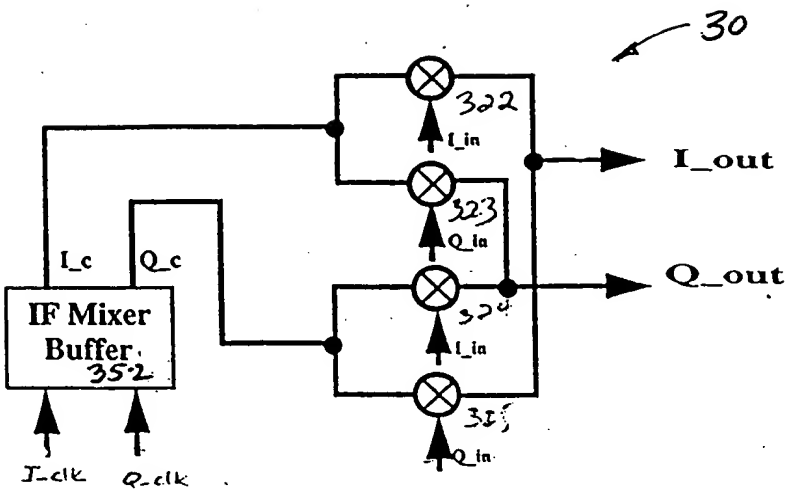
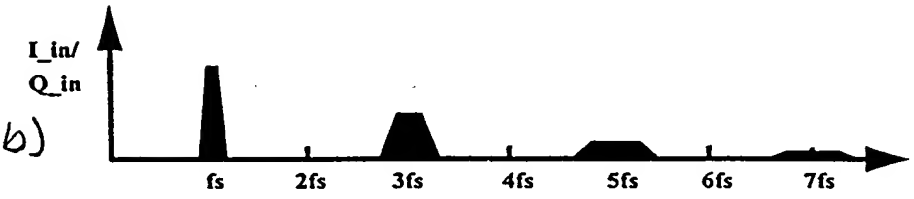
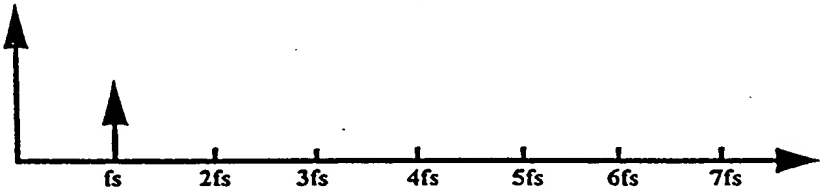


FIG. 17(b)



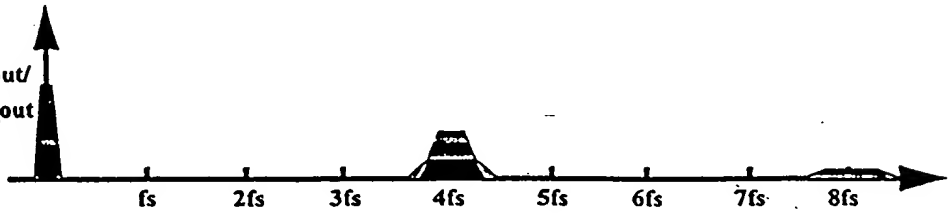
Limited IF Signal Spectrum

FIG. 17(c)



Sinusoidal Input Spectrum

FIG. 17(d)



IF MixerOutput Spectrum

FIG. 18

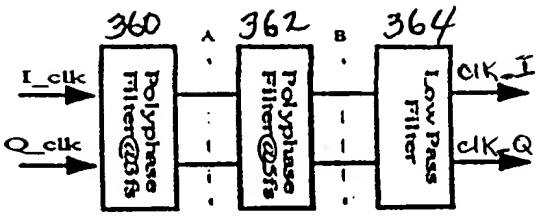
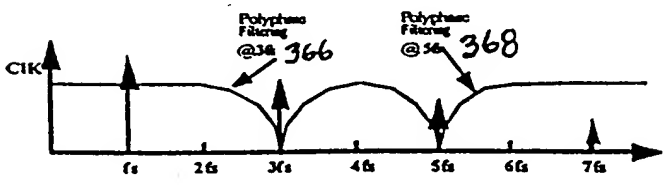
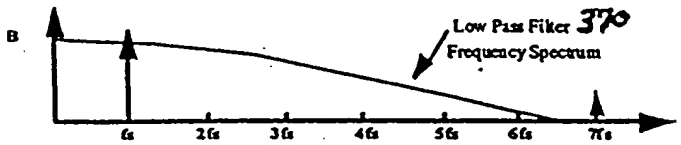


FIG. 19(a)



Differential Input Clock Signal Spectrum

FIG. 19(b)



Signal Spectrum After 3fs and 5fs Polyphase

FIG. 19(c)

Sinusoidal Signal Generation After Low Pass Filter

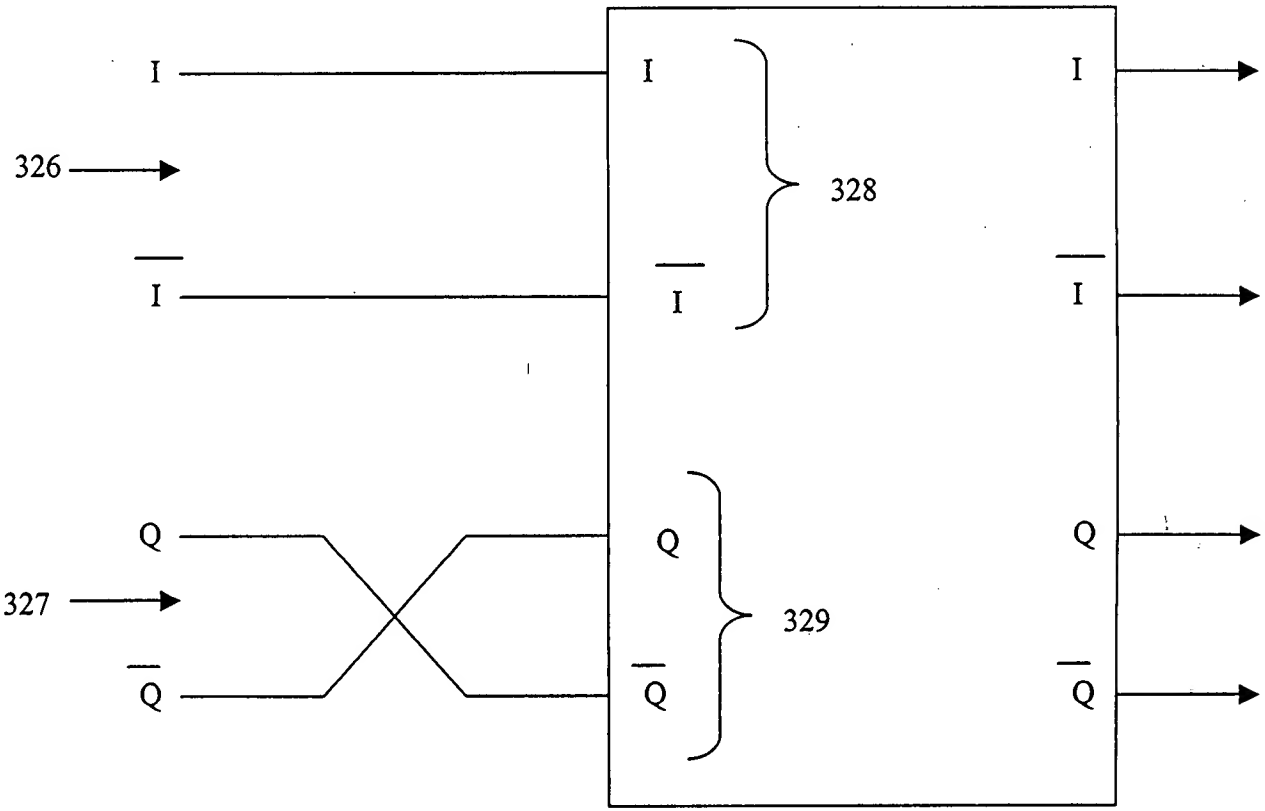

I
326
$\overline{I}$
Q
327
$\overline{Q}$
I
$\overline{I}$
328
Q
$\overline{Q}$
329
I
$\overline{I}$
Q
$\overline{Q}$

FIG. 19d

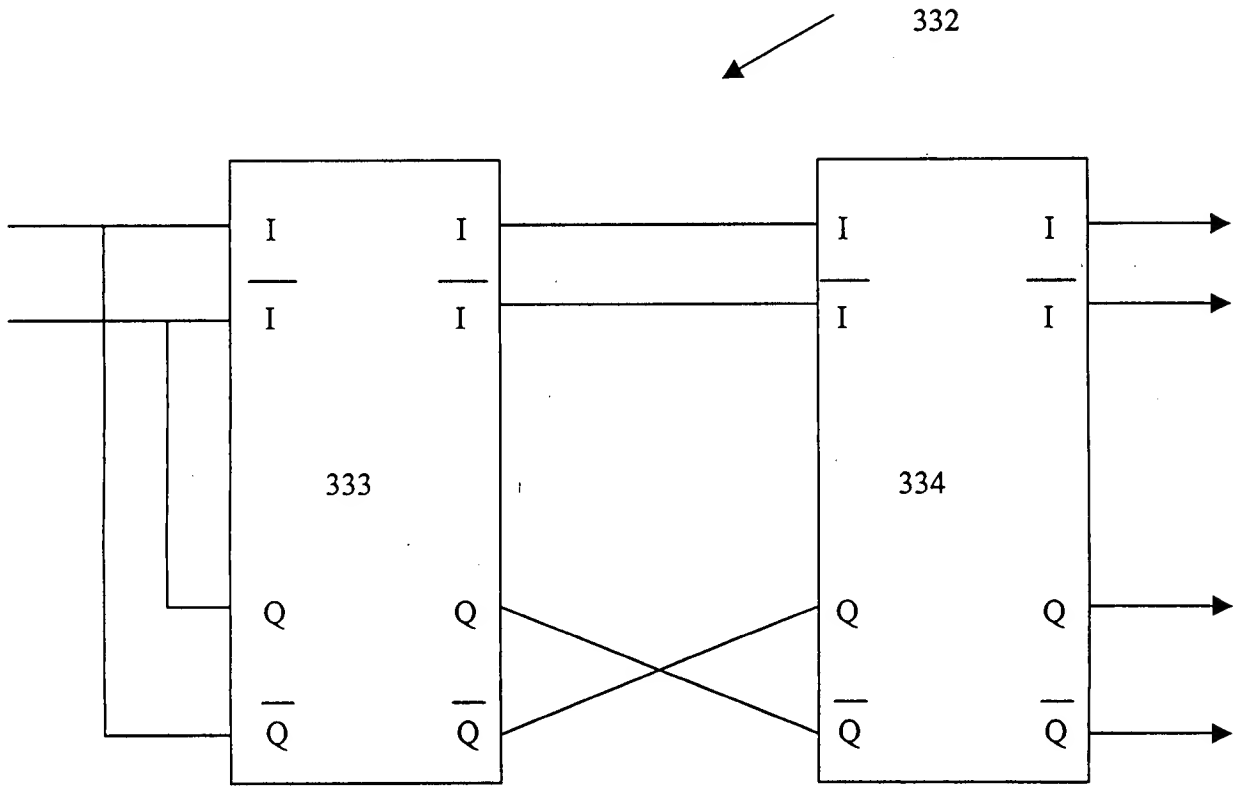


FIG. 19e

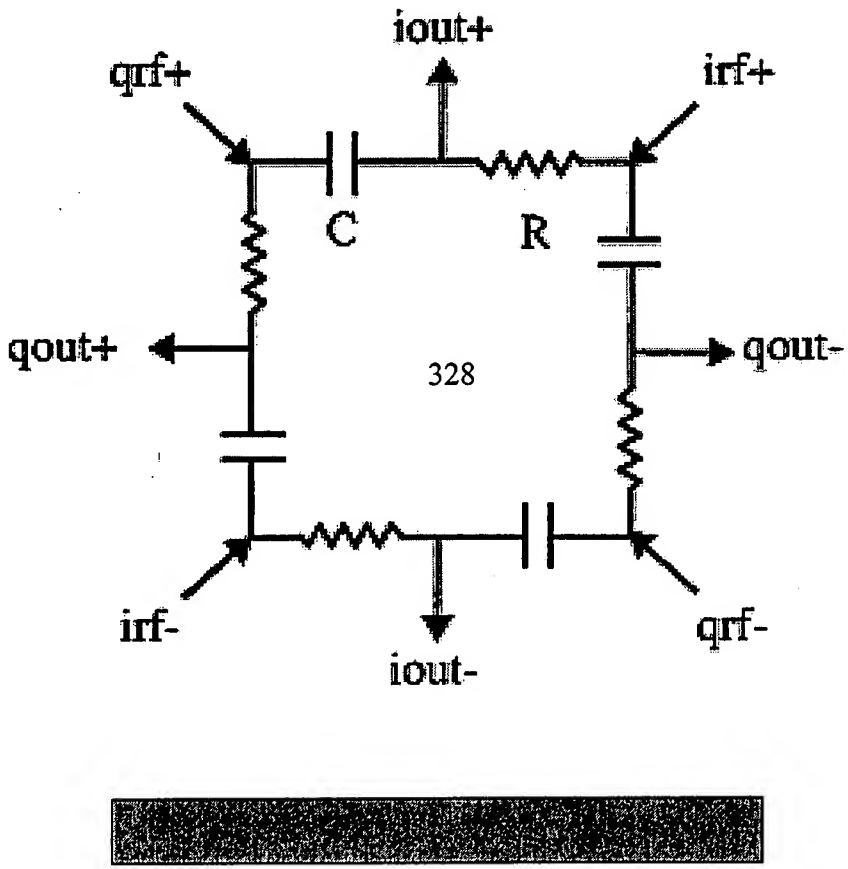
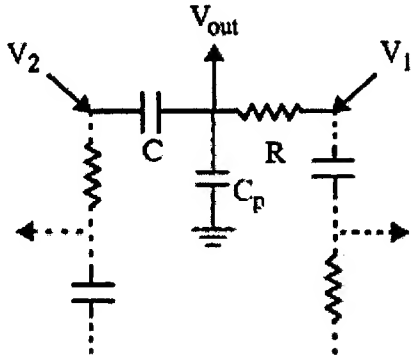


FIG. 19f

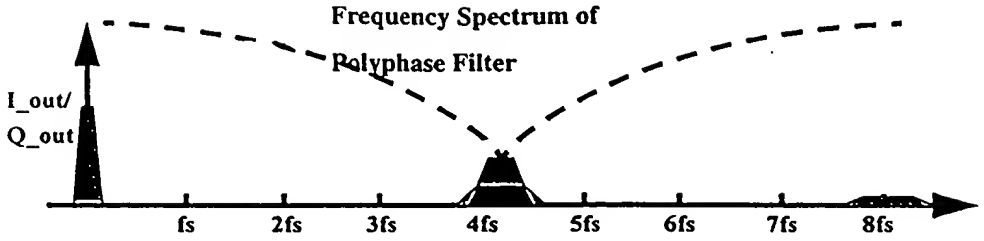


$$\omega_p = \frac{1}{R(C_p + C)}$$

$$\omega_o = \frac{1}{RC}$$

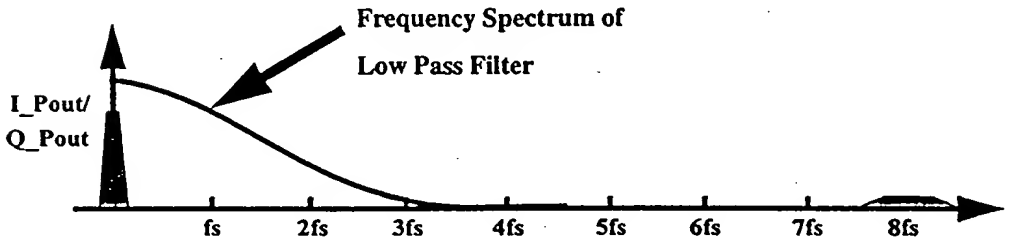
$$V_{out} = \frac{V_1}{R(C_p + C)s + 1} + \frac{V_2 RCs}{R(C_p + C)s + 1}$$

FIG. 19g



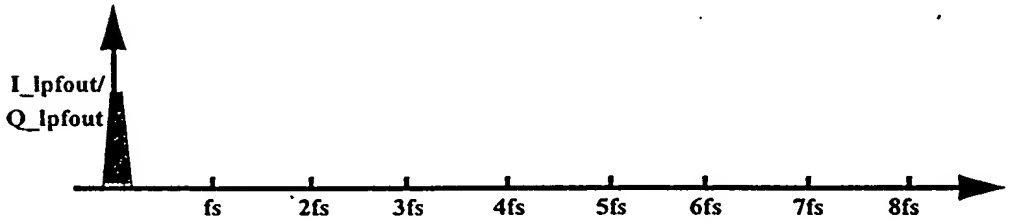
Signal Spectrum at Polyphase Input

FIG. 20(a)



Signal Spectrum at Polyphase Output

FIG. 20(b)



Signal Spectrum at Low Pass Filter Output

FIG. 20(c)

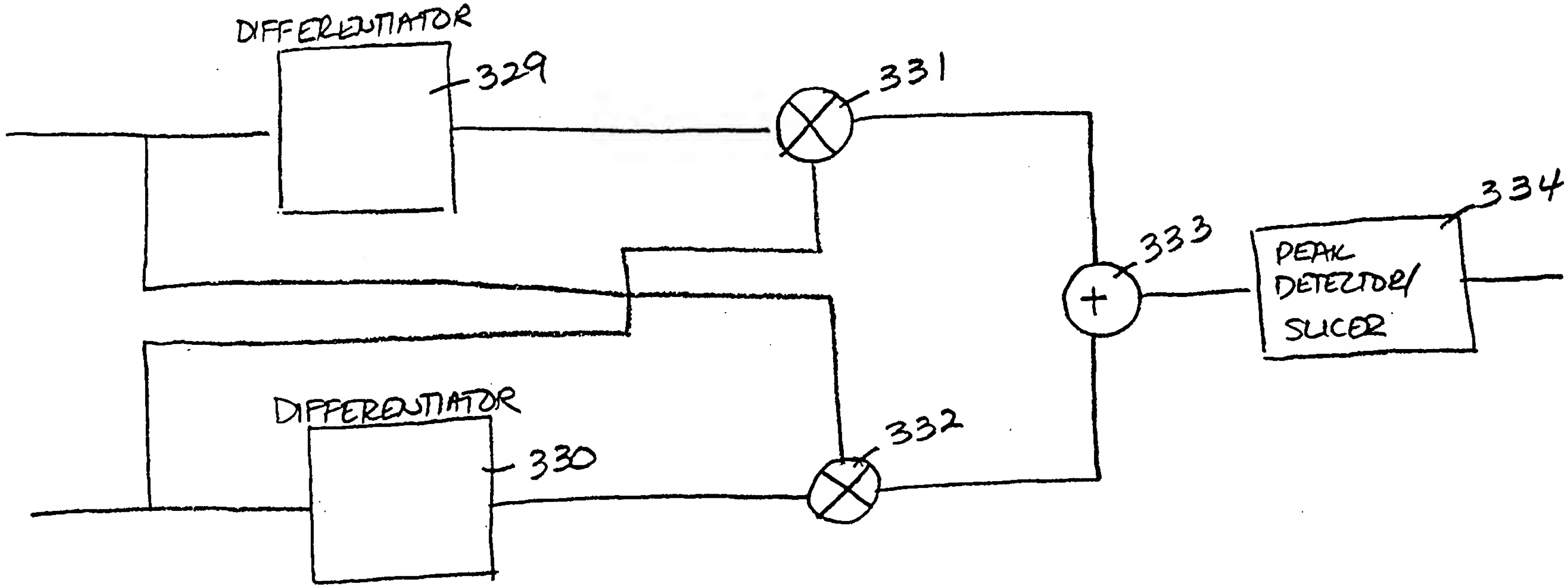

DIFFERENTIATOR
329
DIFFERENTIATOR
330
331
332
333
+
PEAK DETECTOR/ SLICER
334

FIG. 21

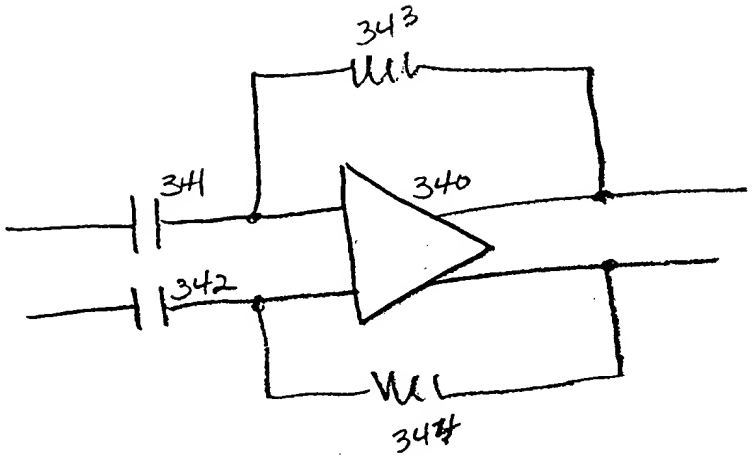


FIGURE 22

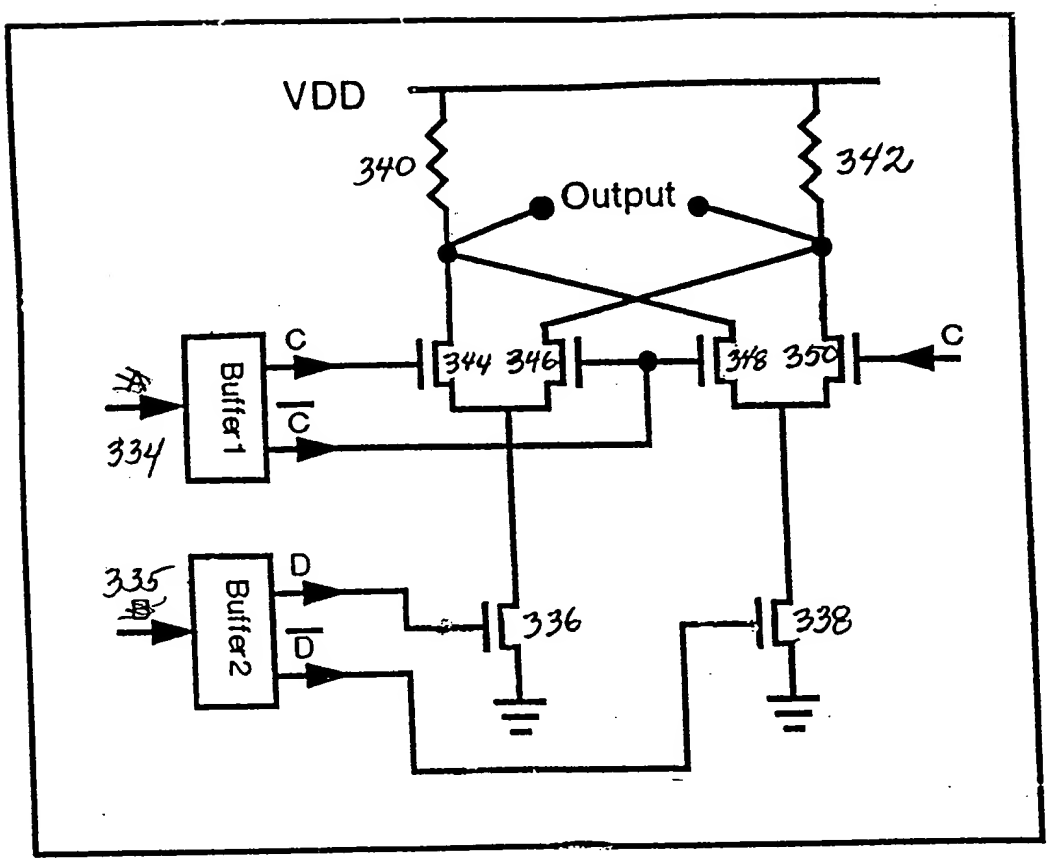

VDD
340
342
Output
C
344
346
348
350
C
Buffer1
334
D
335
Buffer2
D
336
338

FIG. 23

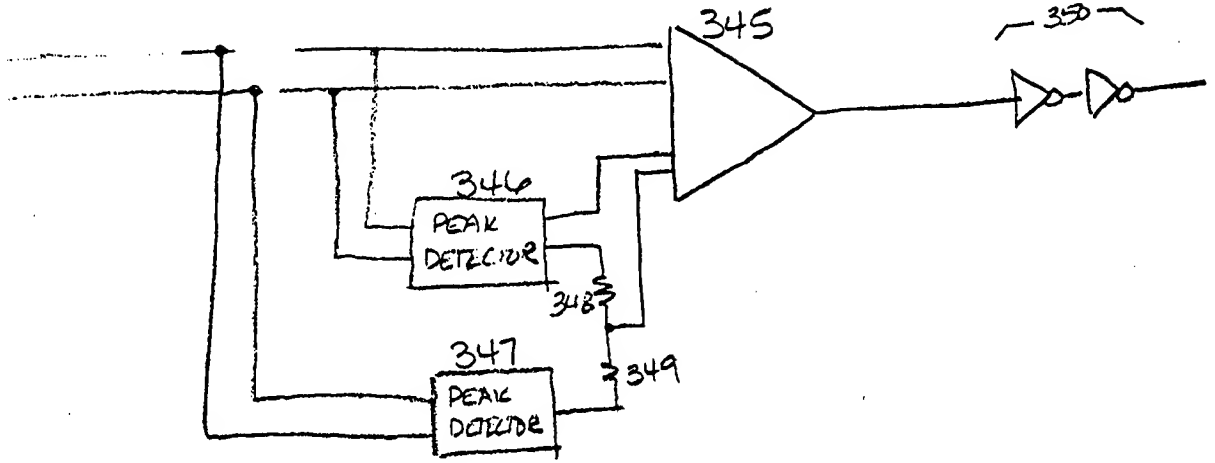


FIGURE 24

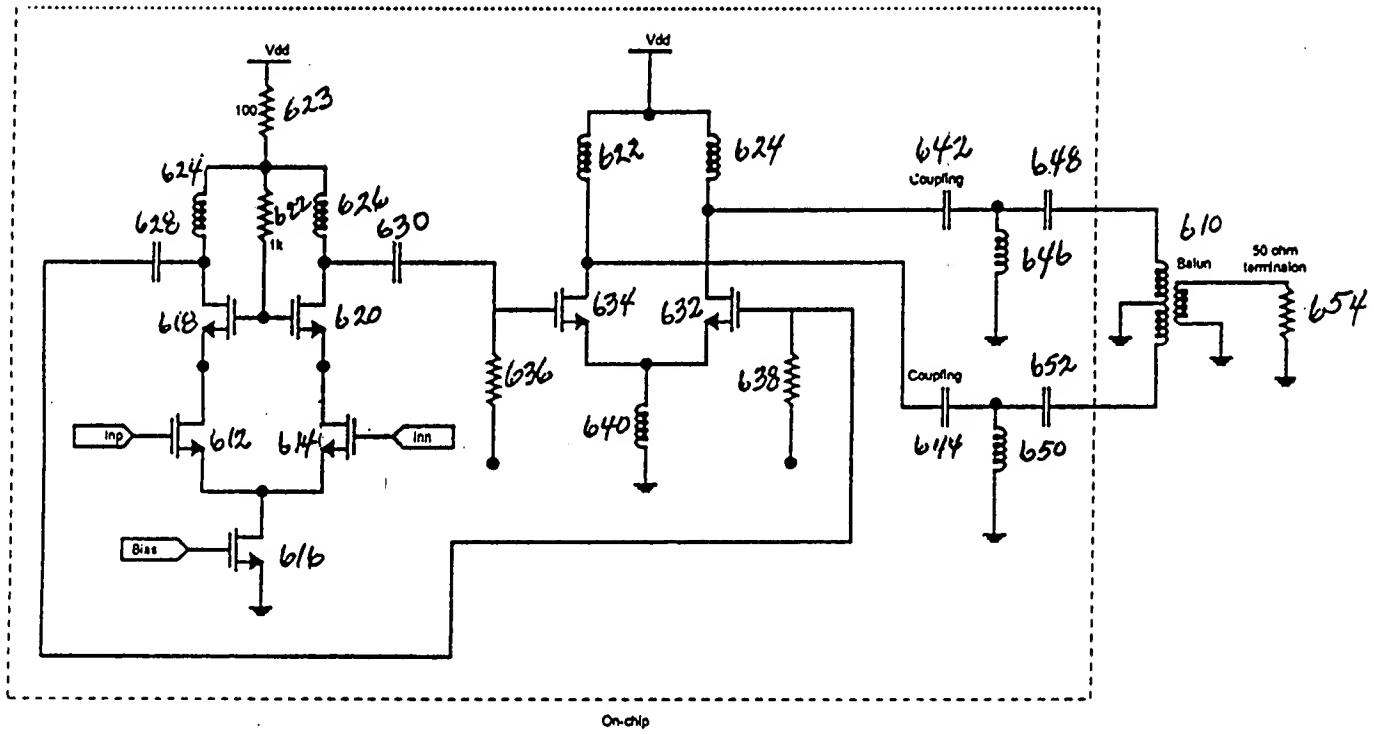

Vdd
100
623
624
628
622
1k
626
630
618
620
inp
612
614
inn
Bias
616
636
Vdd
622
624
634
632
638
640
642
Coupling
648
646
610
Balun
50 ohm
termination
654
Coupling
652
614
650
On-chip

FIG. 25

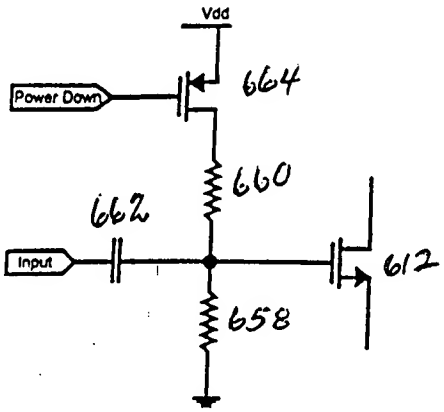


FIG. 26(a)

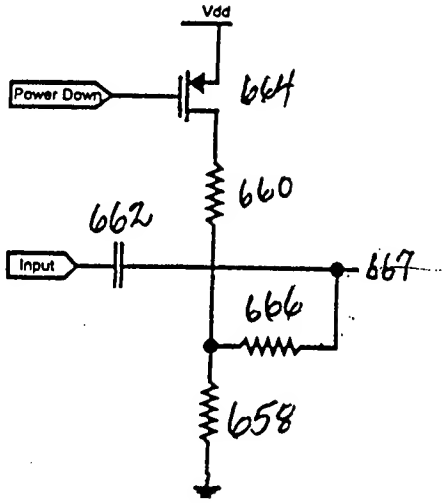


FIG. 26(b)

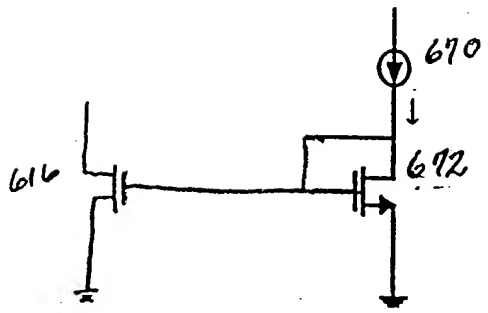


FIG. 27

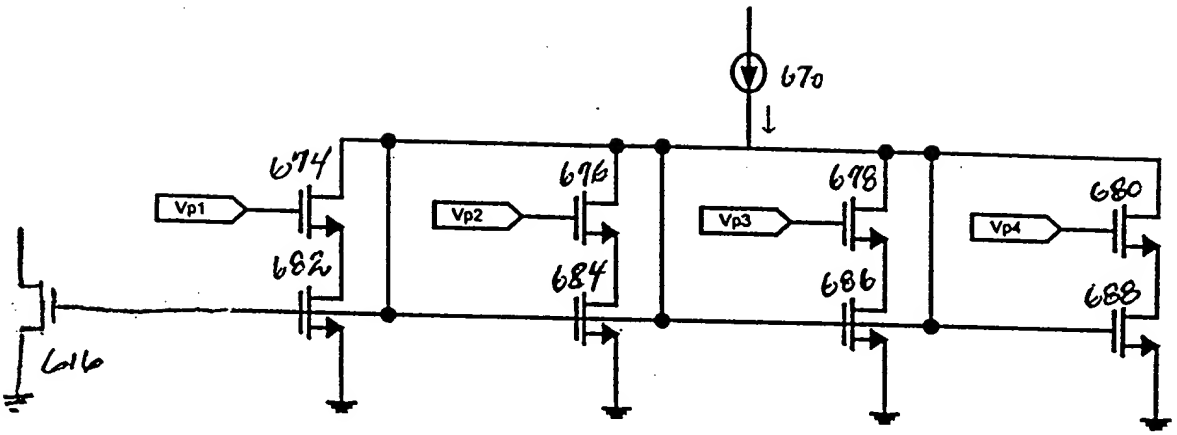


FIG. 28

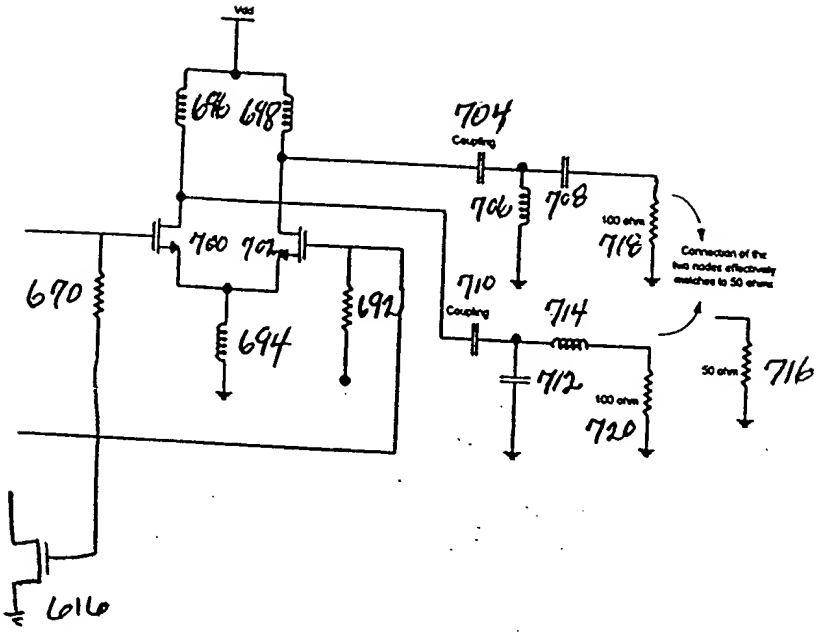

Vdd
686
688
704
Coupling
706
708
100 ohm
718
Connection of the two nodes effectively switches to 50 ohms
700
702
670
692
710
Coupling
714
694
712
50 ohm
716
100 ohm
720
616

FIG. 29

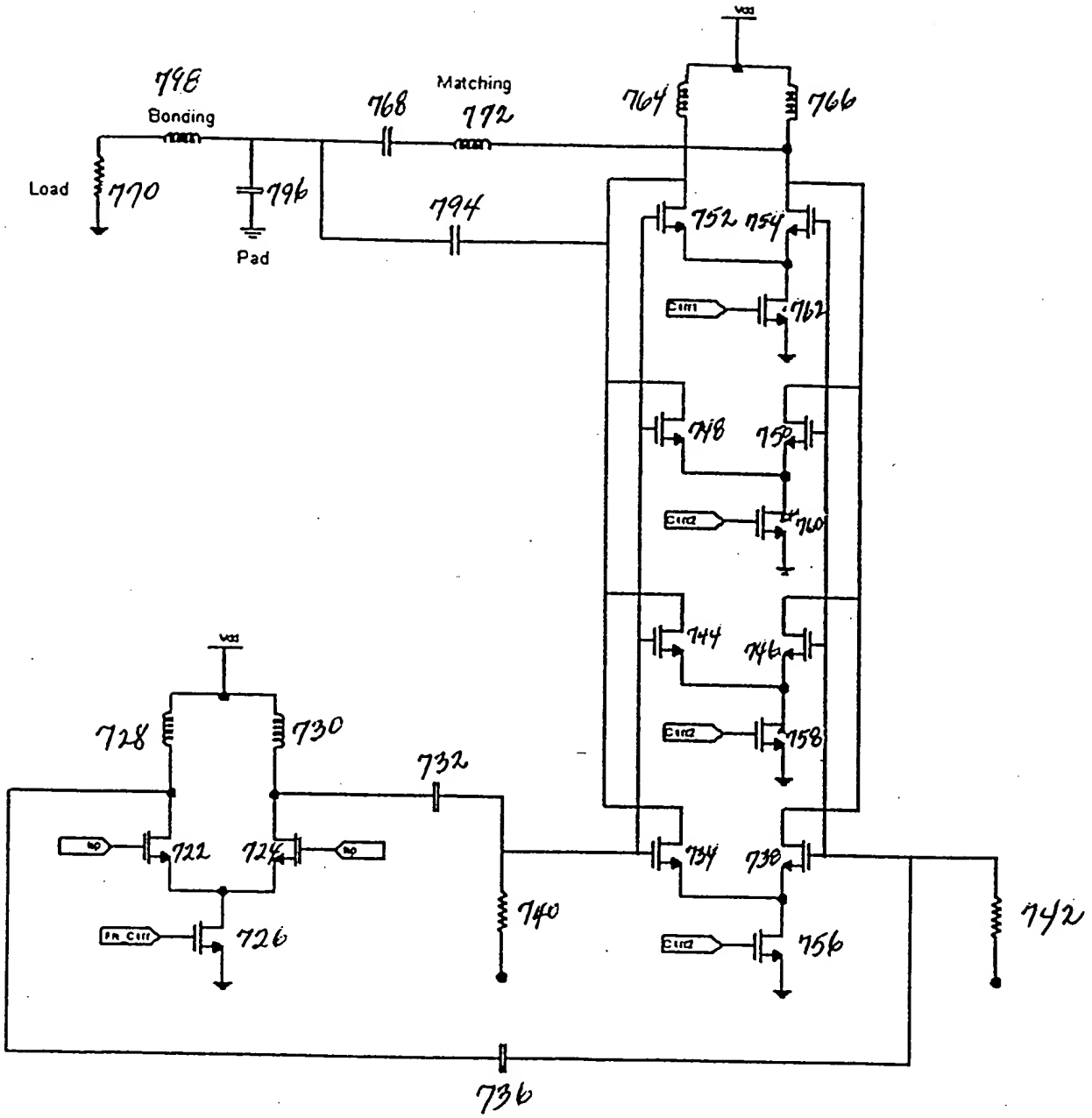

798
Bonding
768
Matching
772
764
766
Load
770
796
Pad
794
752
754
762
748
750
760
744
746
758
728
730
732
722
724
726
734
738
740
742
756
736

FIG. 30A

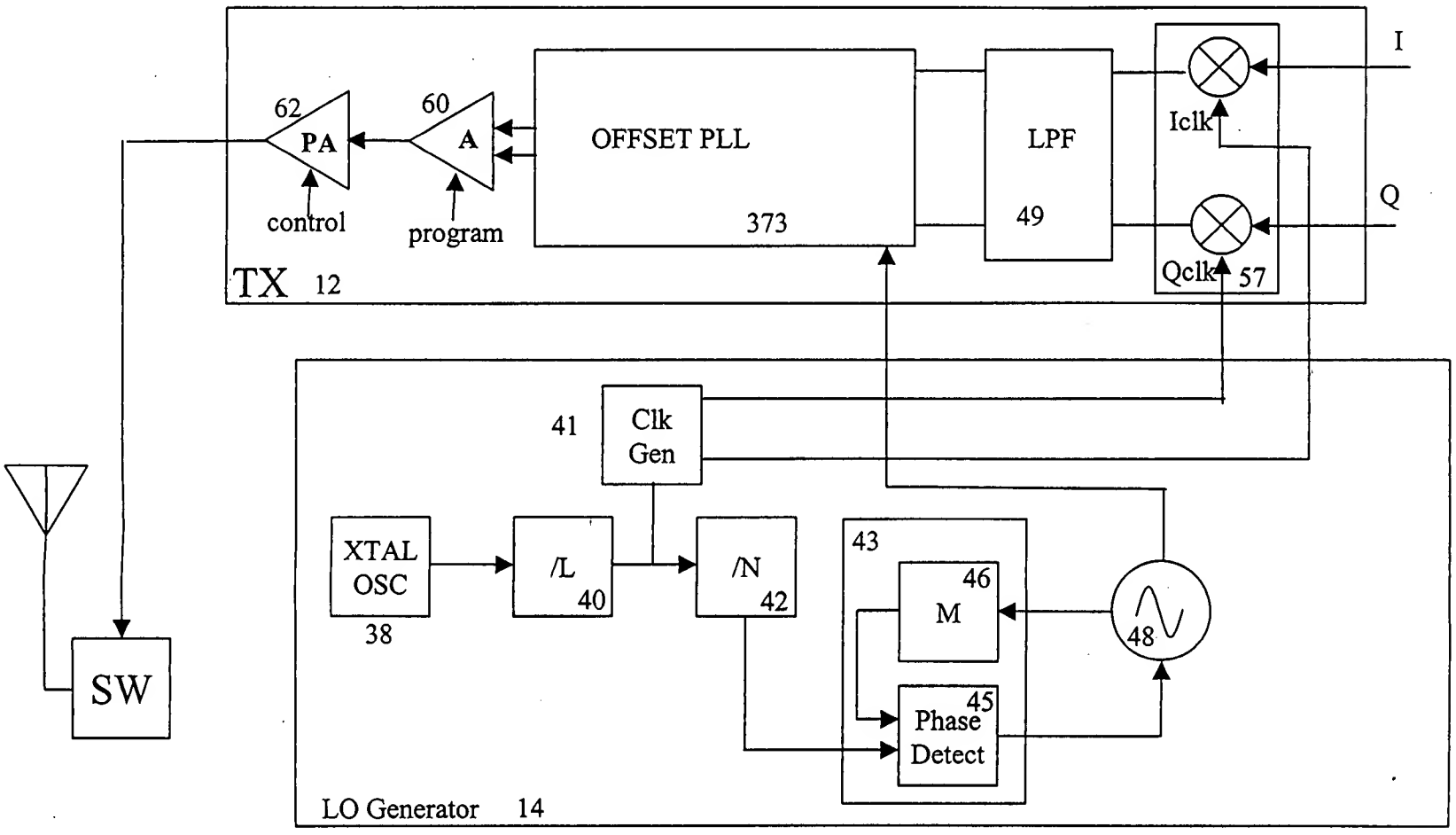

62
PA
60
A
OFFSET PLL
373
LPF
49
I
Iclk
Q
Qclk
57
control
program
TX 12
41
Clk
Gen
XTAL
OSC
38
/L
40
/N
42
43
46
M
48
45
Phase
Detect
LO Generator 14
SW

FIG. 30b

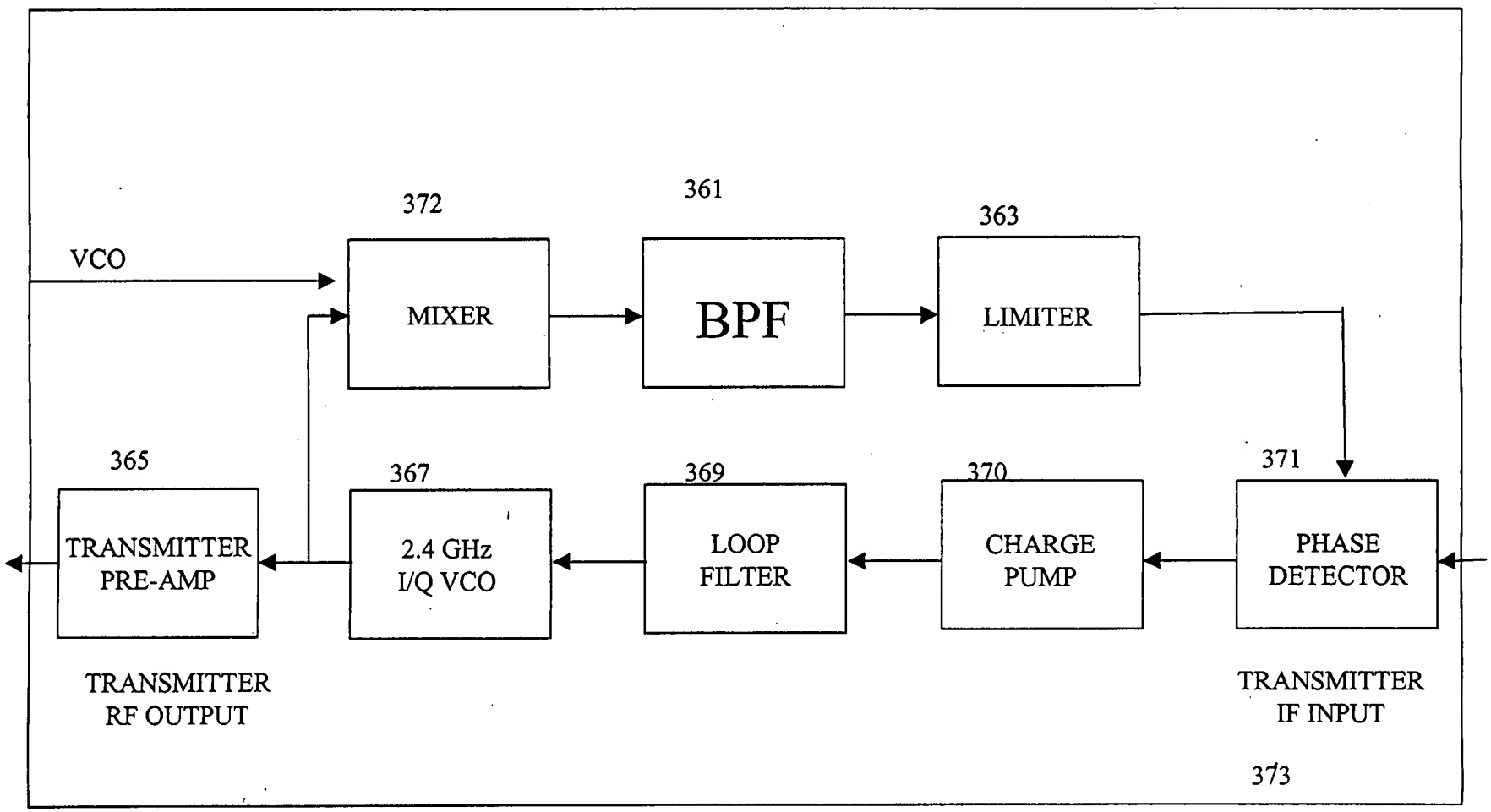

372
361
363
VCO
MIXER
BPF
LIMITER
365
367
369
370
371
TRANSMITTER
PRE-AMP
2.4 GHz
I/Q VCO
LOOP
FILTER
CHARGE
PUMP
PHASE
DETECTOR
TRANSMITTER
RF OUTPUT
TRANSMITTER
IF INPUT
373

FIG. 30c

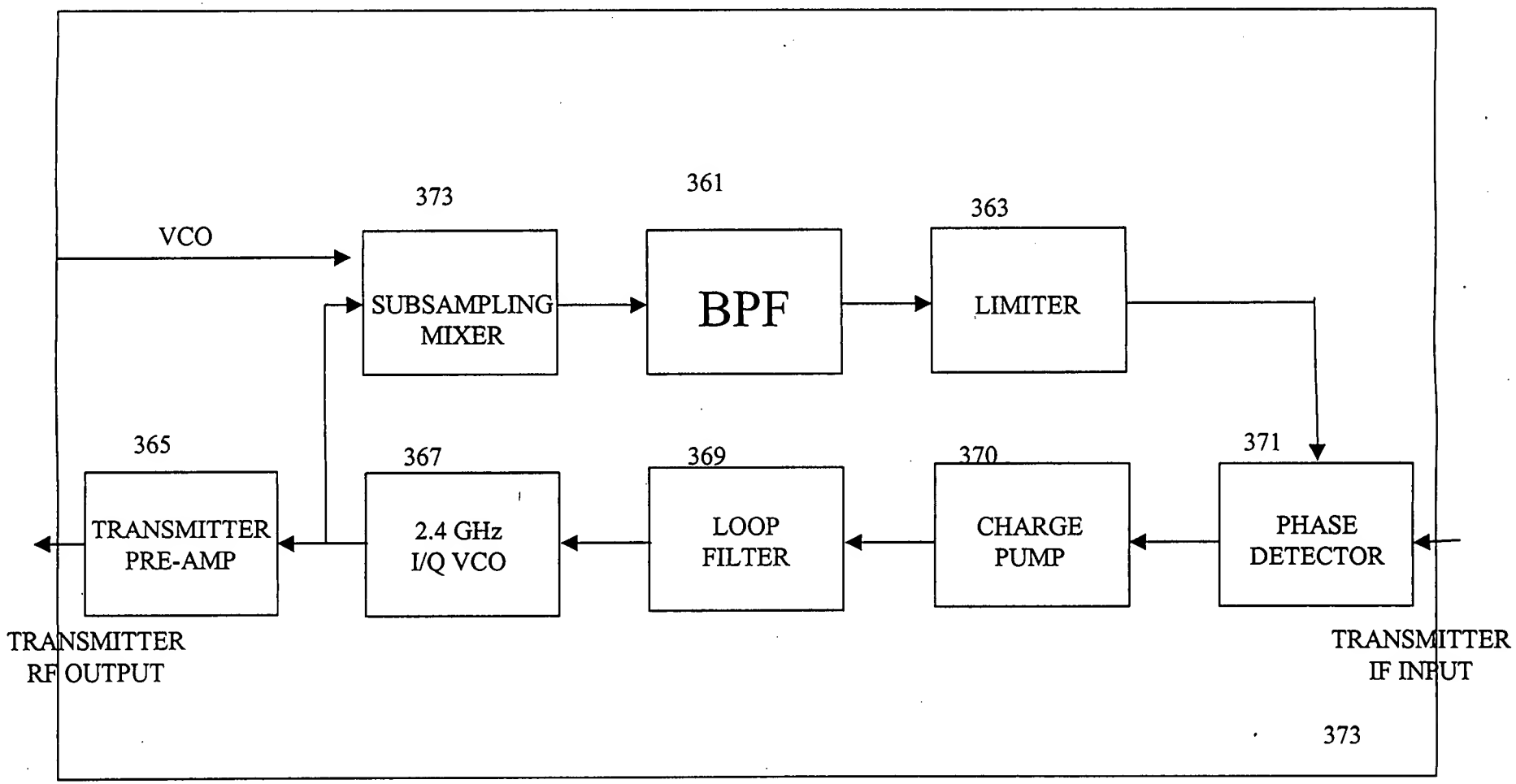

373
361
363
VCO
SUBSAMPLING MIXER
BPF
LIMITER
365
367
369
370
371
TRANSMITTER PRE-AMP
2.4 GHz I/Q VCO
LOOP FILTER
CHARGE PUMP
PHASE DETECTOR
TRANSMITTER RF OUTPUT
TRANSMITTER IF INPUT
373

FIG. 30d

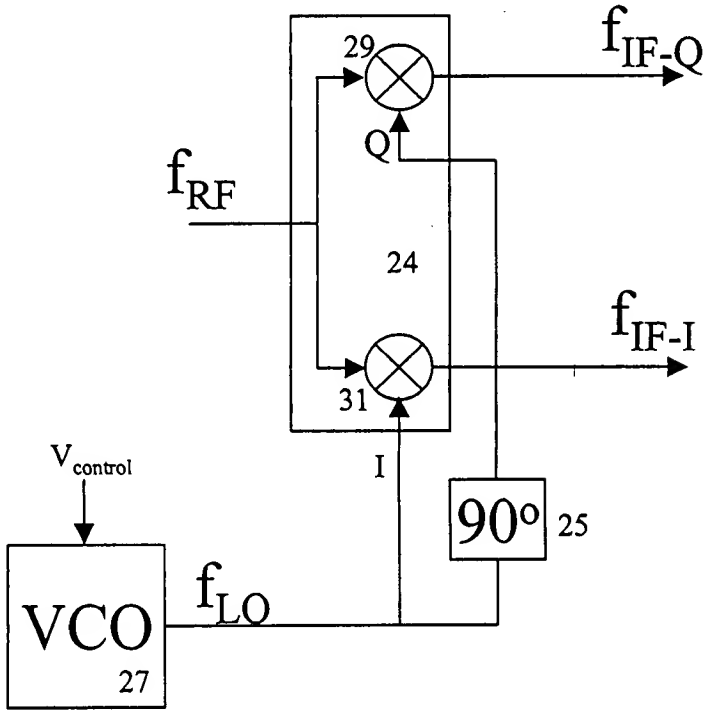


FIG. 30e

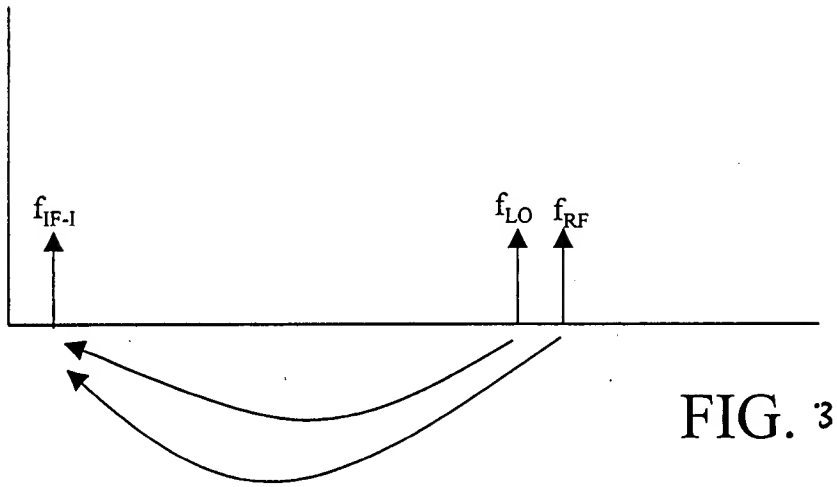


FIG. 30f

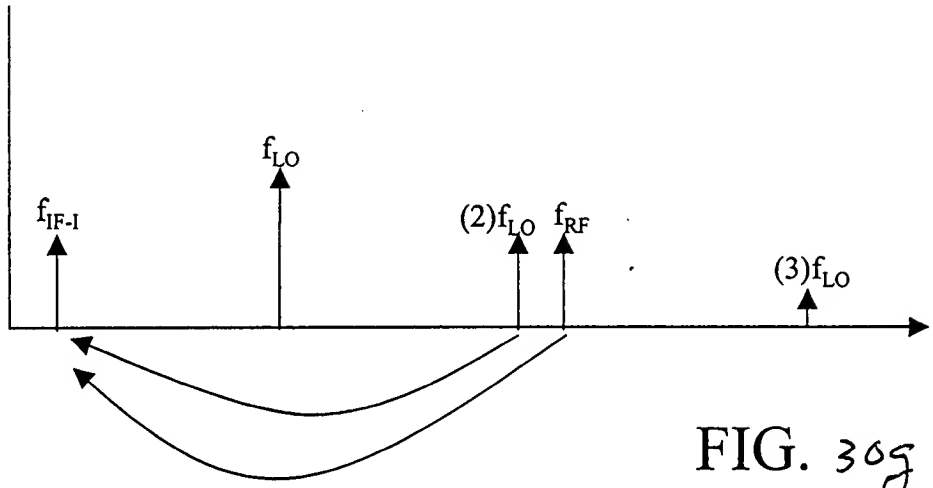


FIG. 30g

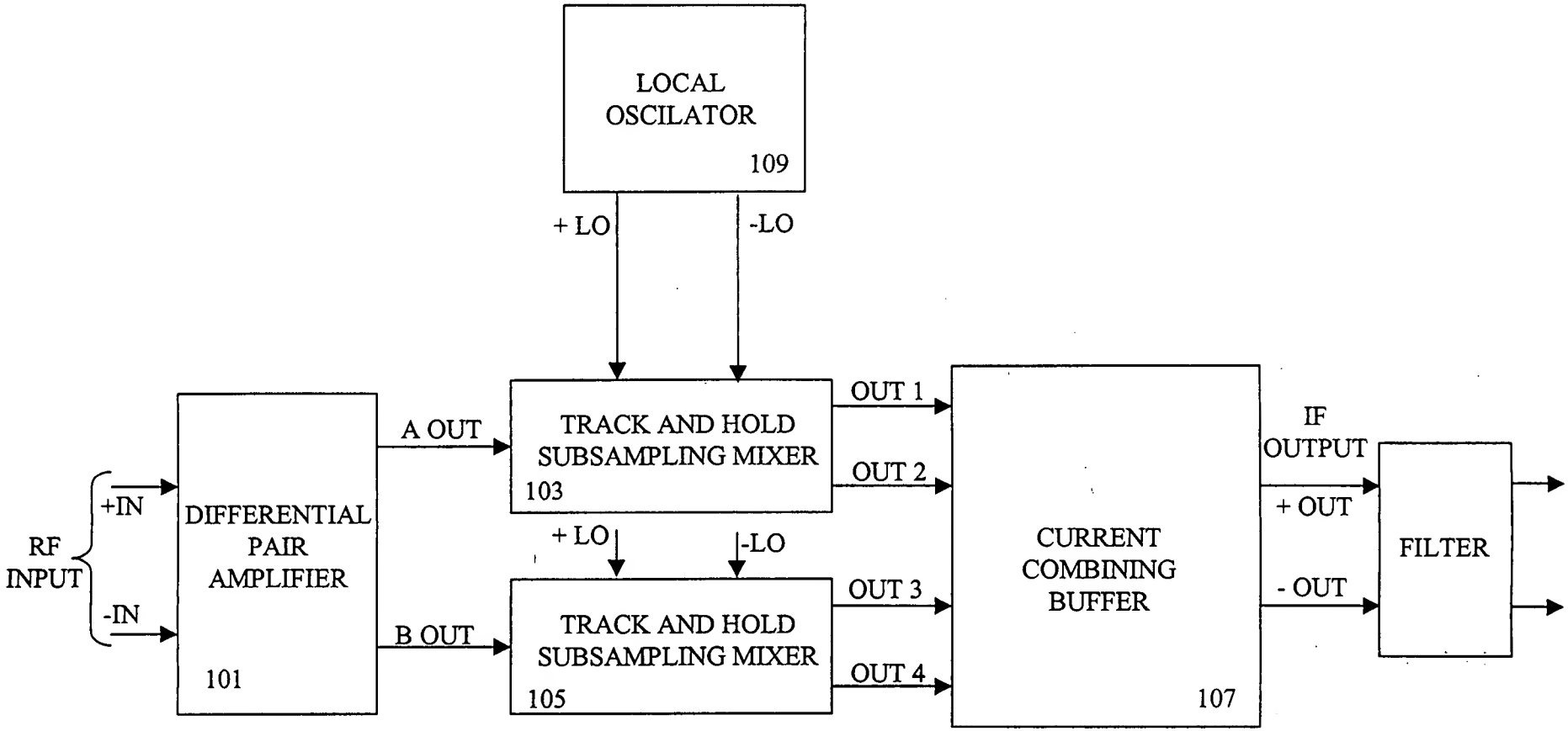

LOCAL
OSCILATOR
109
+ LO
-LO
RF
INPUT
+IN
-IN
DIFFERENTIAL
PAIR
AMPLIFIER
101
A OUT
B OUT
TRACK AND HOLD
SUBSAMPLING MIXER
103
+ LO
-LO
TRACK AND HOLD
SUBSAMPLING MIXER
105
OUT 1
OUT 2
OUT 3
OUT 4
CURRENT
COMBINING
BUFFER
107
IF
OUTPUT
+ OUT
- OUT
FILTER

FIG. 30h

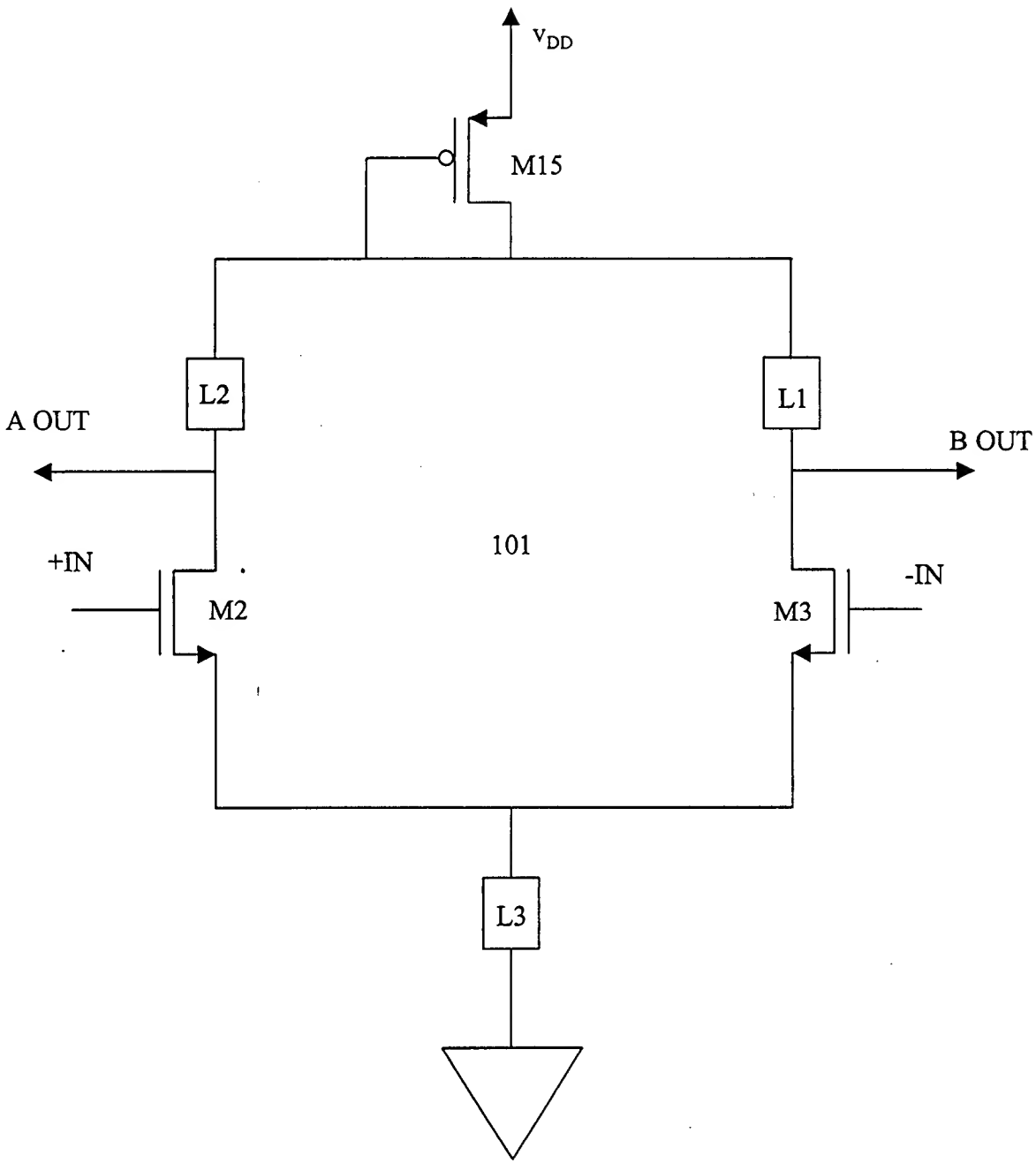


FIG. 30i

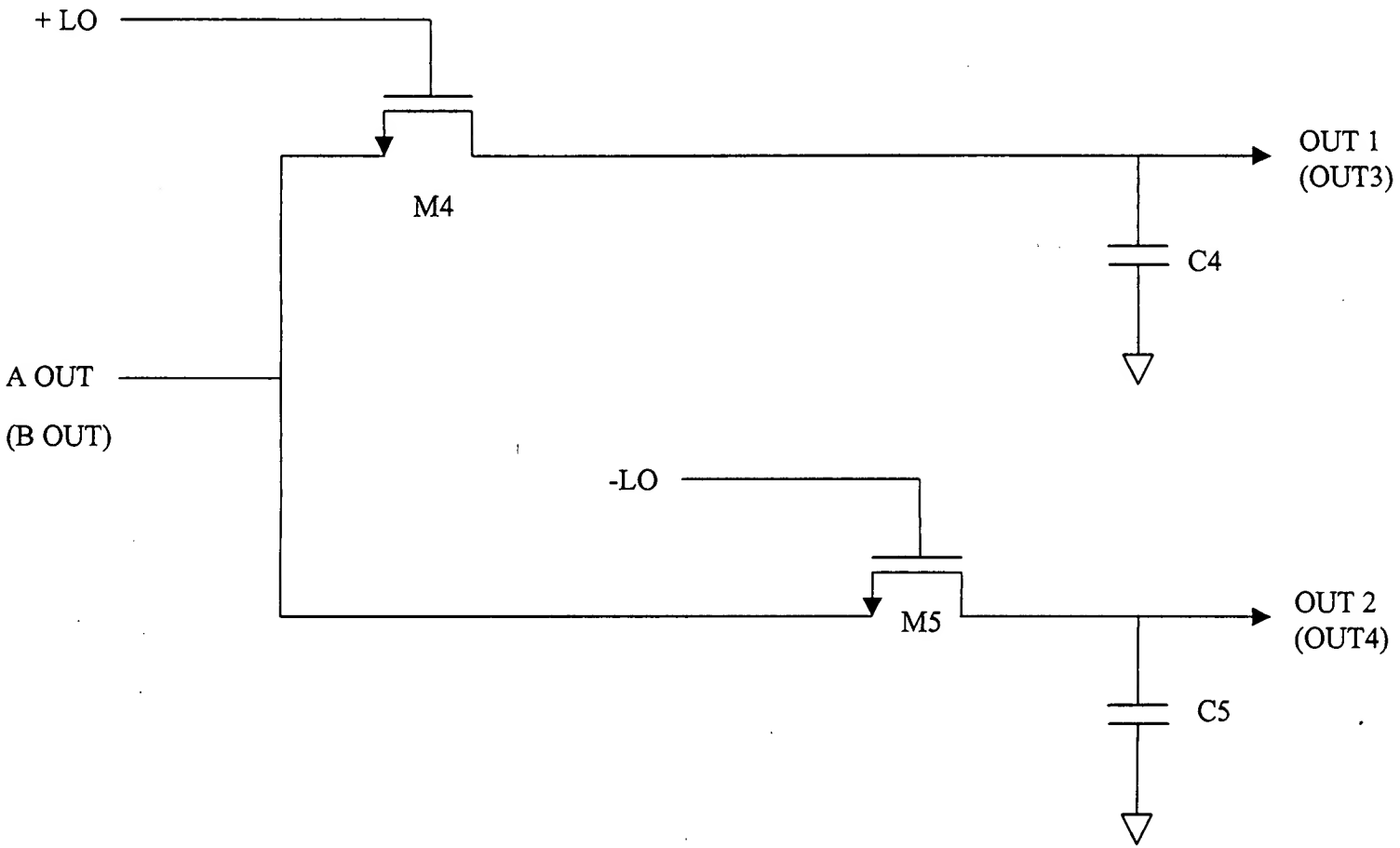


FIG. 30j

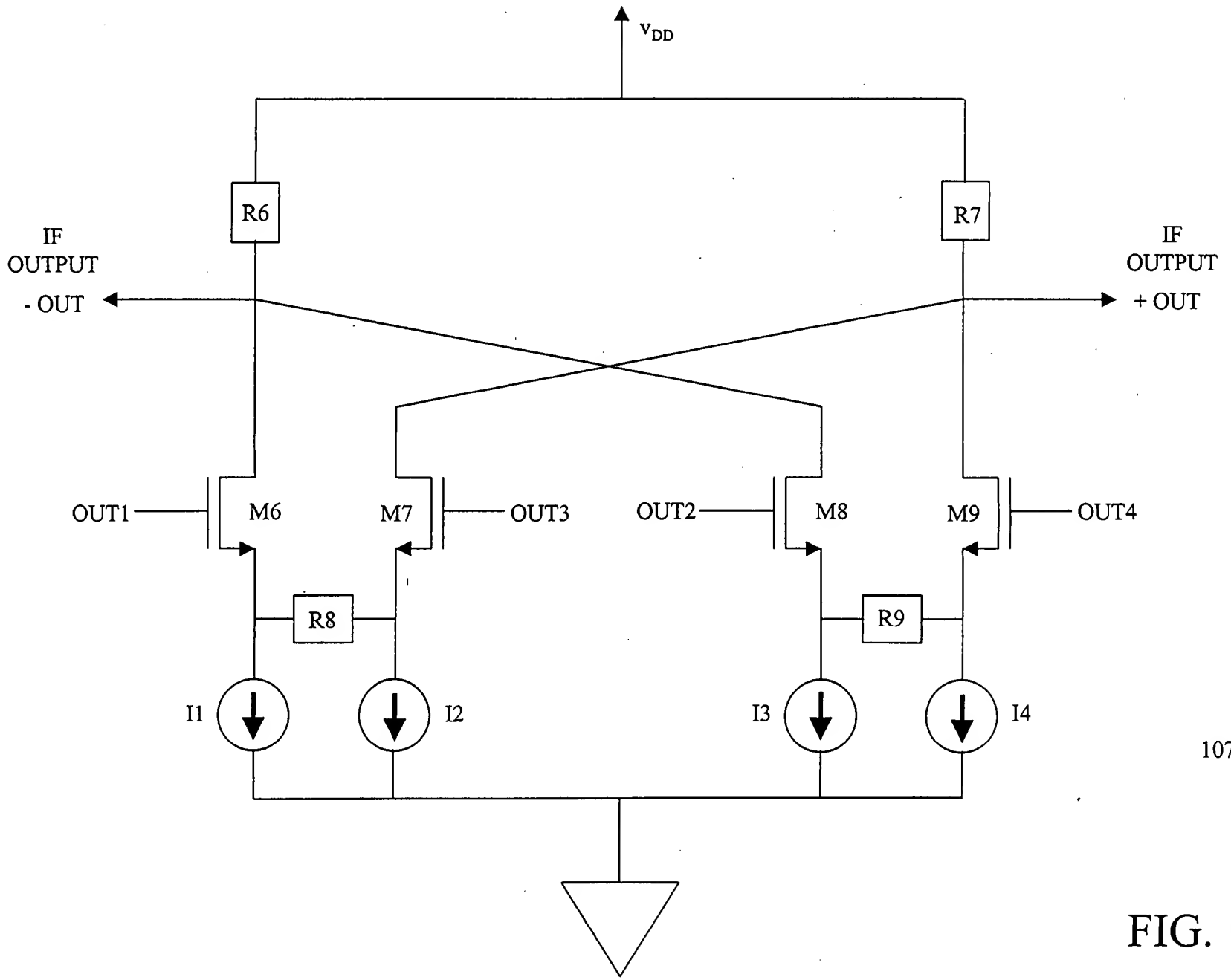
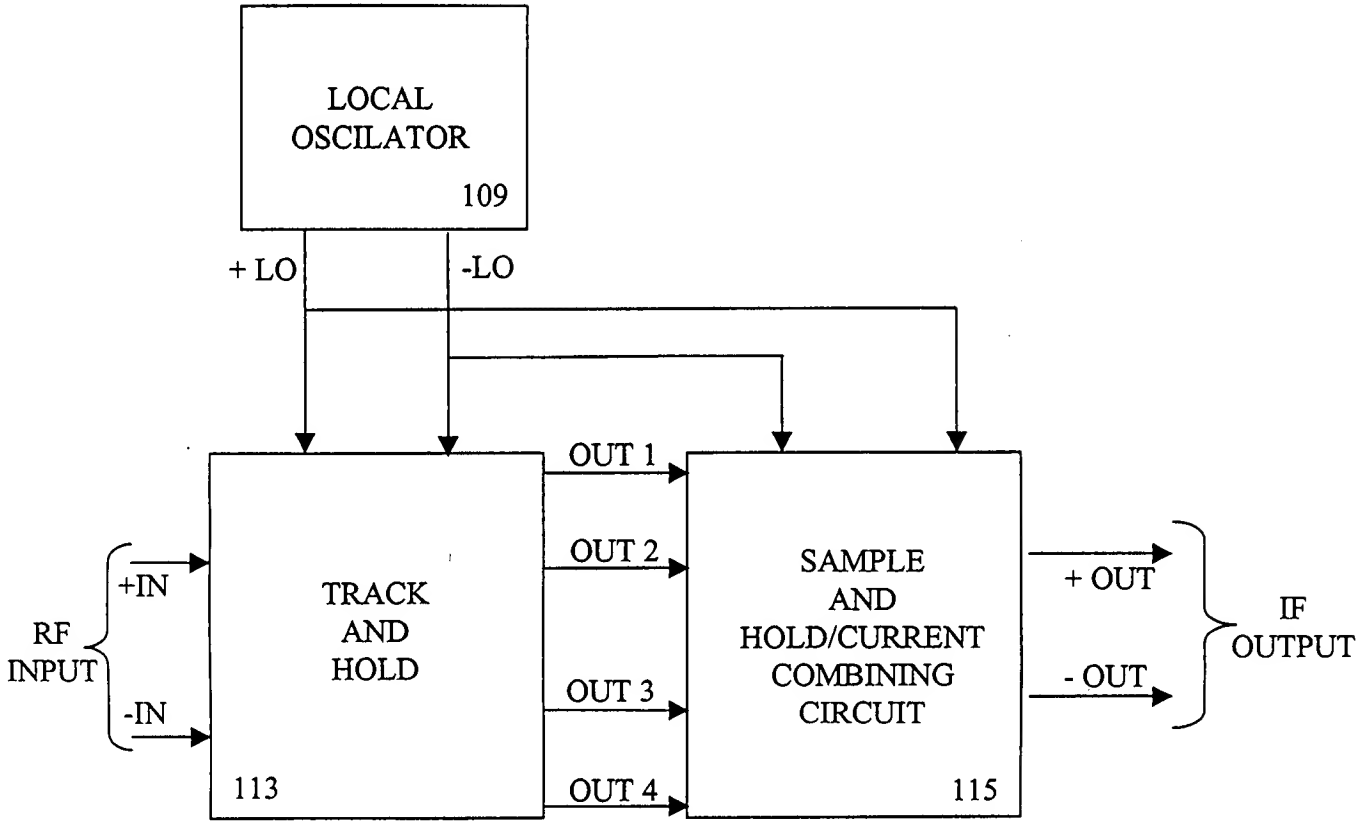

V_{DD}
R6
R7
IF
OUTPUT
- OUT
IF
OUTPUT
+ OUT
OUT1
M6
M7
OUT3
OUT2
M8
M9
OUT4
R8
R9
I1
I2
I3
I4
107

FIG. 30k


LOCAL
OSCILATOR
109
+ LO
-LO
OUT 1
OUT 2
OUT 3
OUT 4
RF
INPUT
+IN
-IN
TRACK
AND
HOLD
113
SAMPLE
AND
HOLD/CURRENT
COMBINING
CIRCUIT
115
+ OUT
- OUT
IF
OUTPUT

111

FIG. 30L

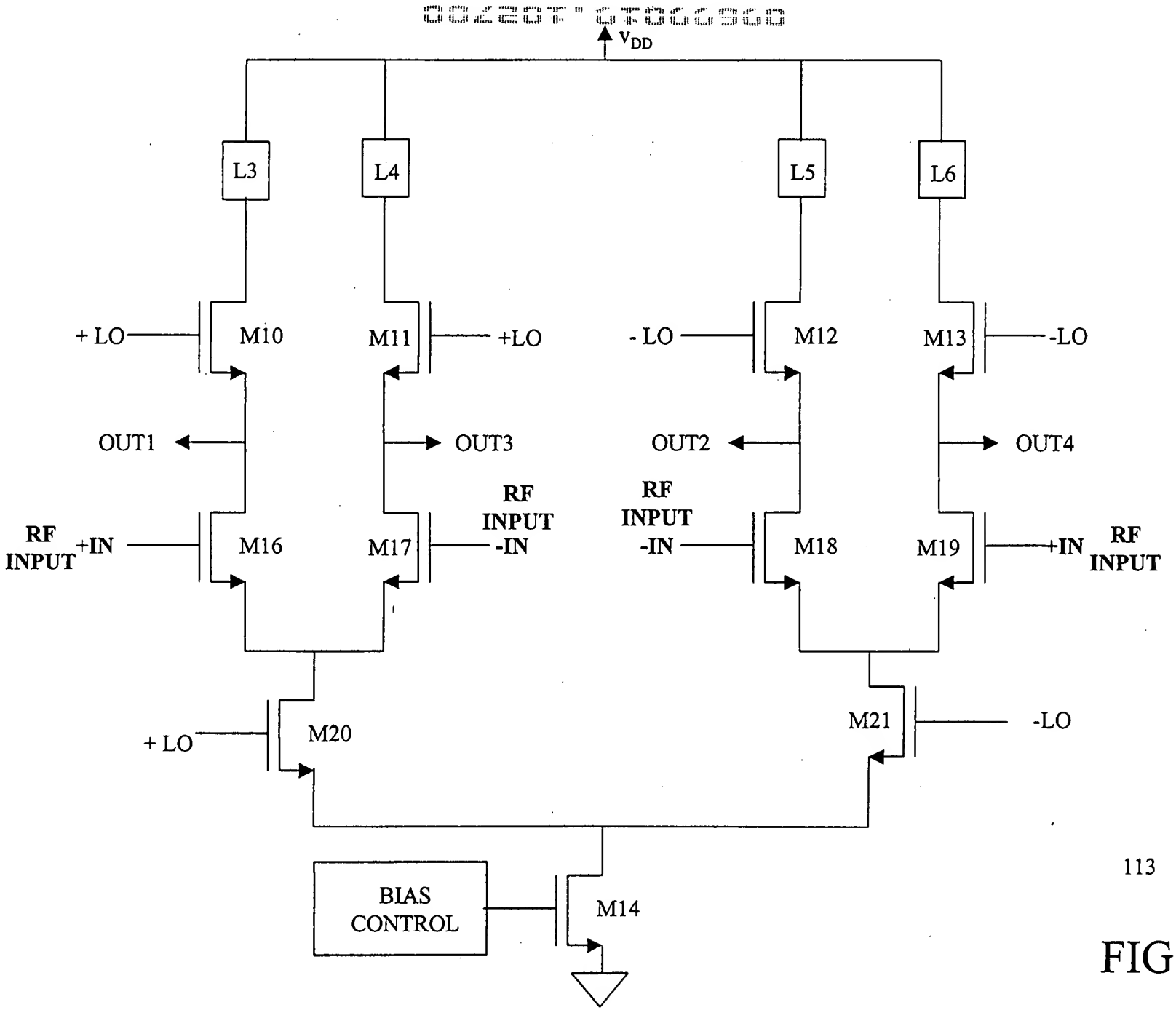

V_{DD}
L3
L4
L5
L6
+ LO
M10
M11
+LO
- LO
M12
M13
-LO
OUT1
OUT3
OUT2
OUT4
RF INPUT +IN
M16
M17
RF INPUT -IN
RF INPUT -IN
M18
M19
+IN RF INPUT
+ LO
M20
M21
-LO
BIAS CONTROL
M14
113

FIG. 30m

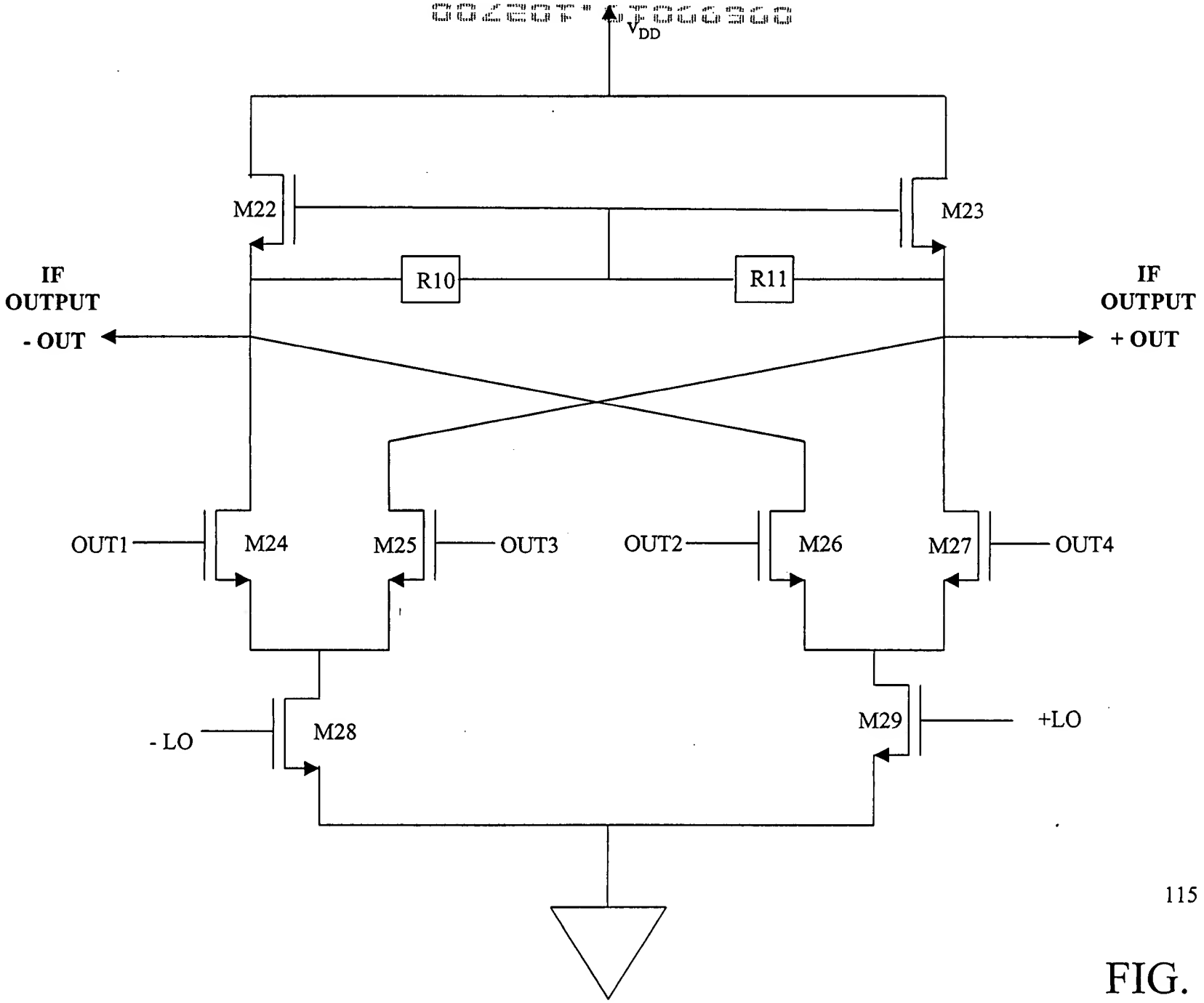

V_{DD}
M22
M23
R10
R11
IF OUTPUT - OUT
IF OUTPUT + OUT
OUT1
M24
M25
OUT3
OUT2
M26
M27
OUT4
- LO
M28
M29
+LO
115

FIG. 30n

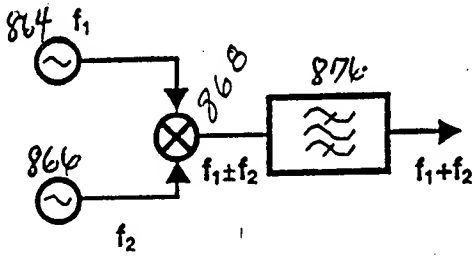


FIG. 31 (a)

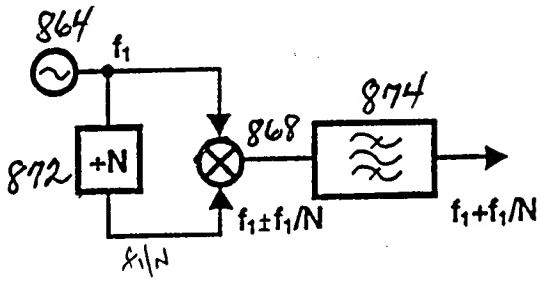


FIG. 31 (b)

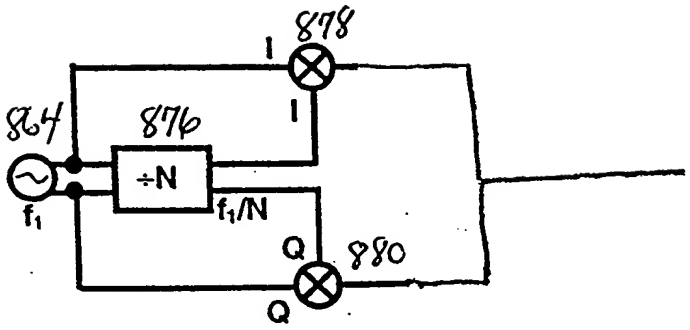


FIG. 32

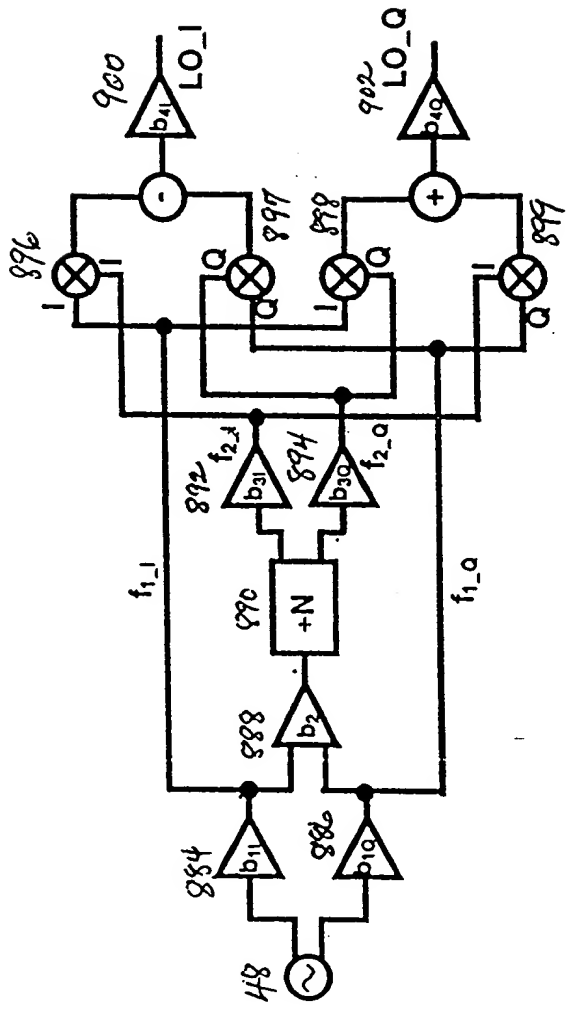

900
LO_I
902
LO_Q
876
878
897
899
892
894
f2_I
f2_Q
f1_I
f1_Q
890
+N
888
884
886
48

FIG. 33(a)

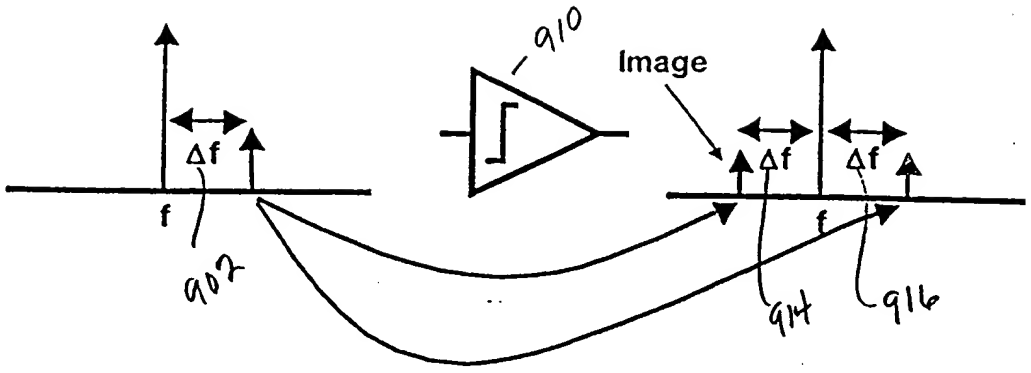


FIG. 33(b)

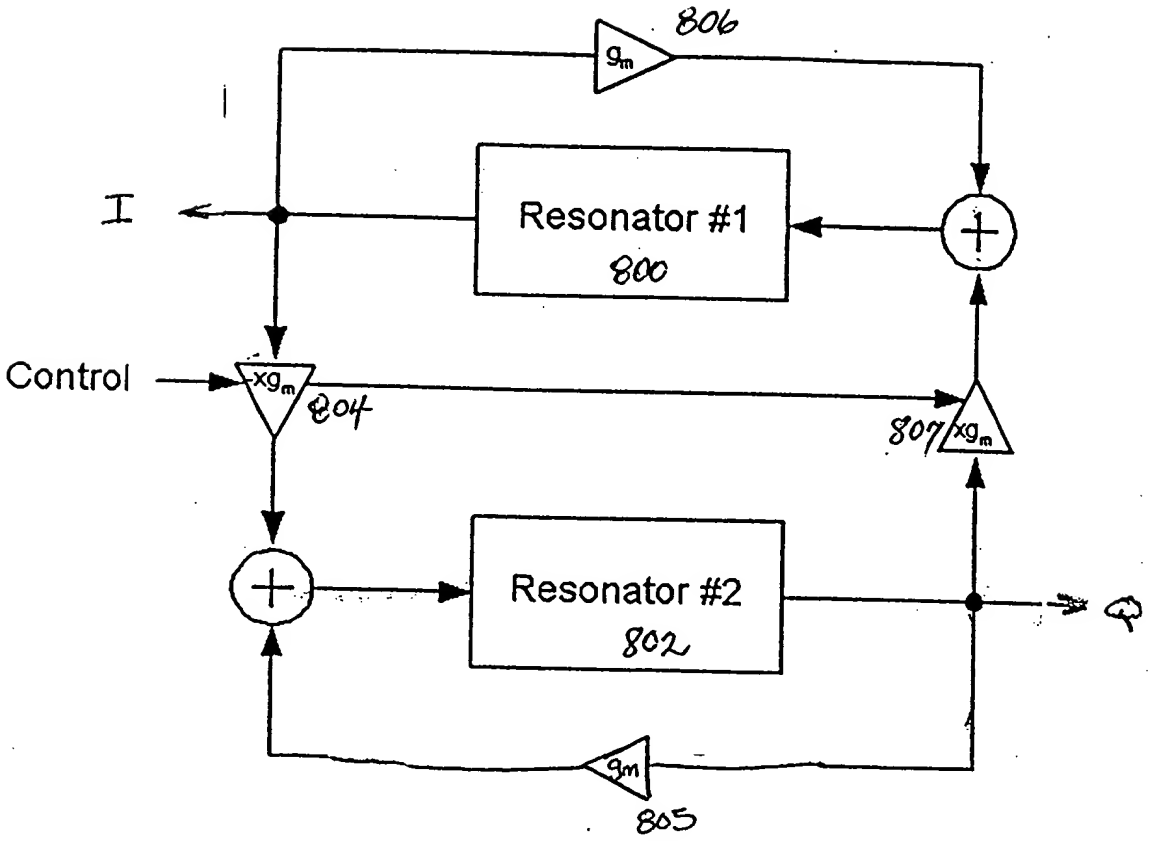

806
g_m
I
Resonator #1
800
Control
xg_m
804
807
xg_m
Resonator #2
802
Q
g_m
805

FIG. 34

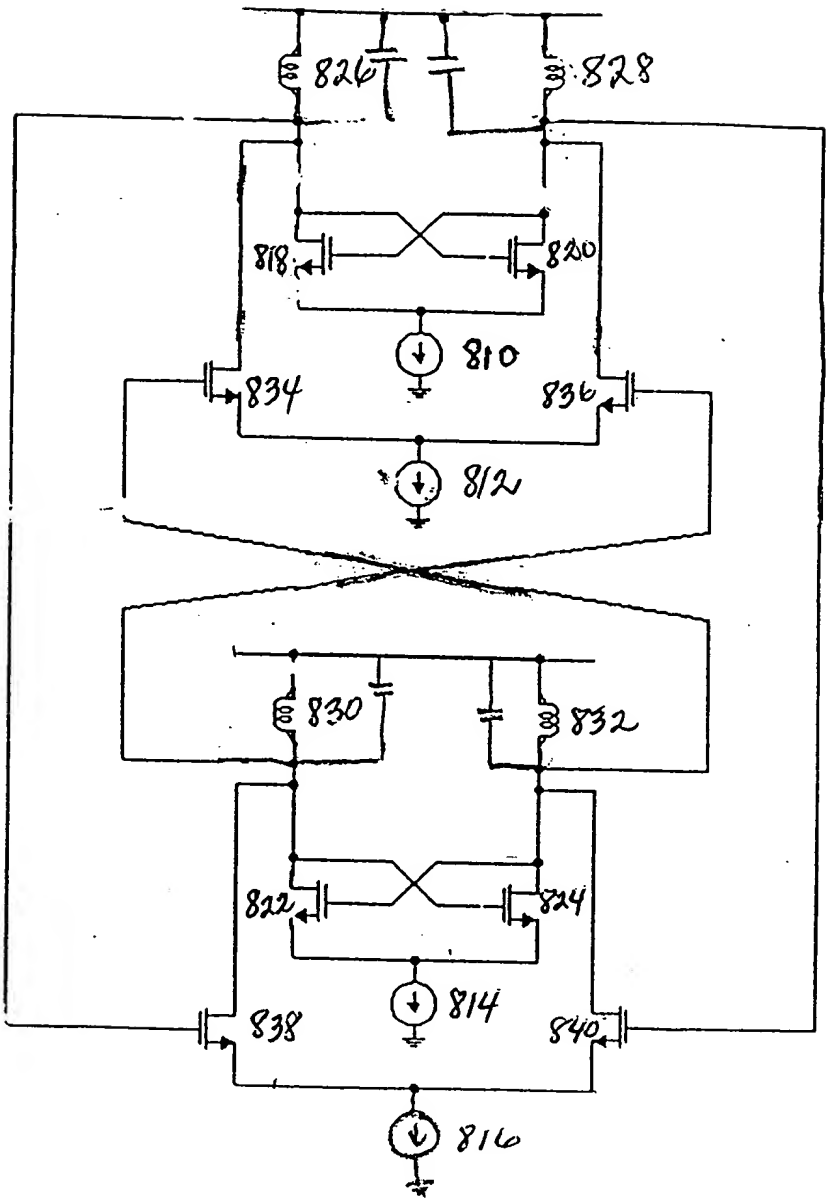
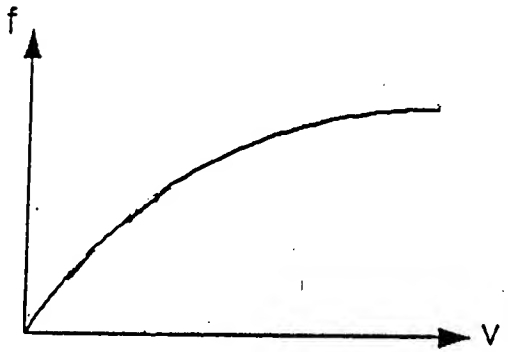
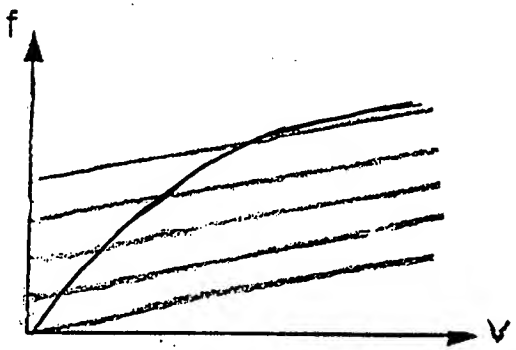


FIG. 35



Typical VCO Tuning Curve

FIG. 36(a)



Segmented VCO Tuning Curve

FIG. 36(b)

FIG. 37(a)

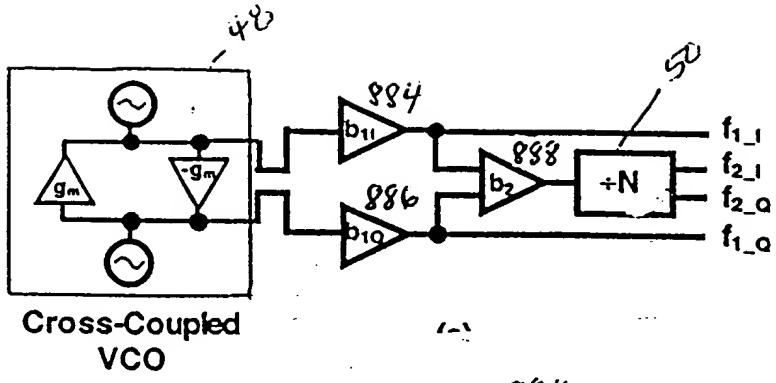
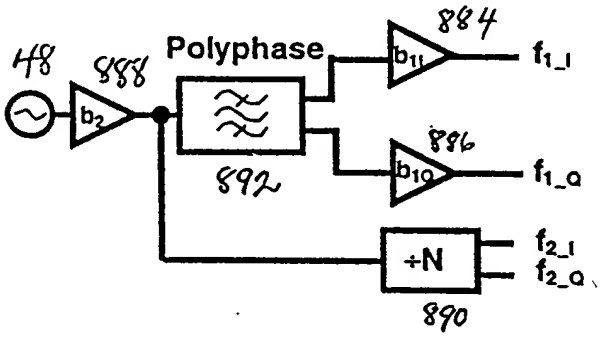


FIG. 37(b)



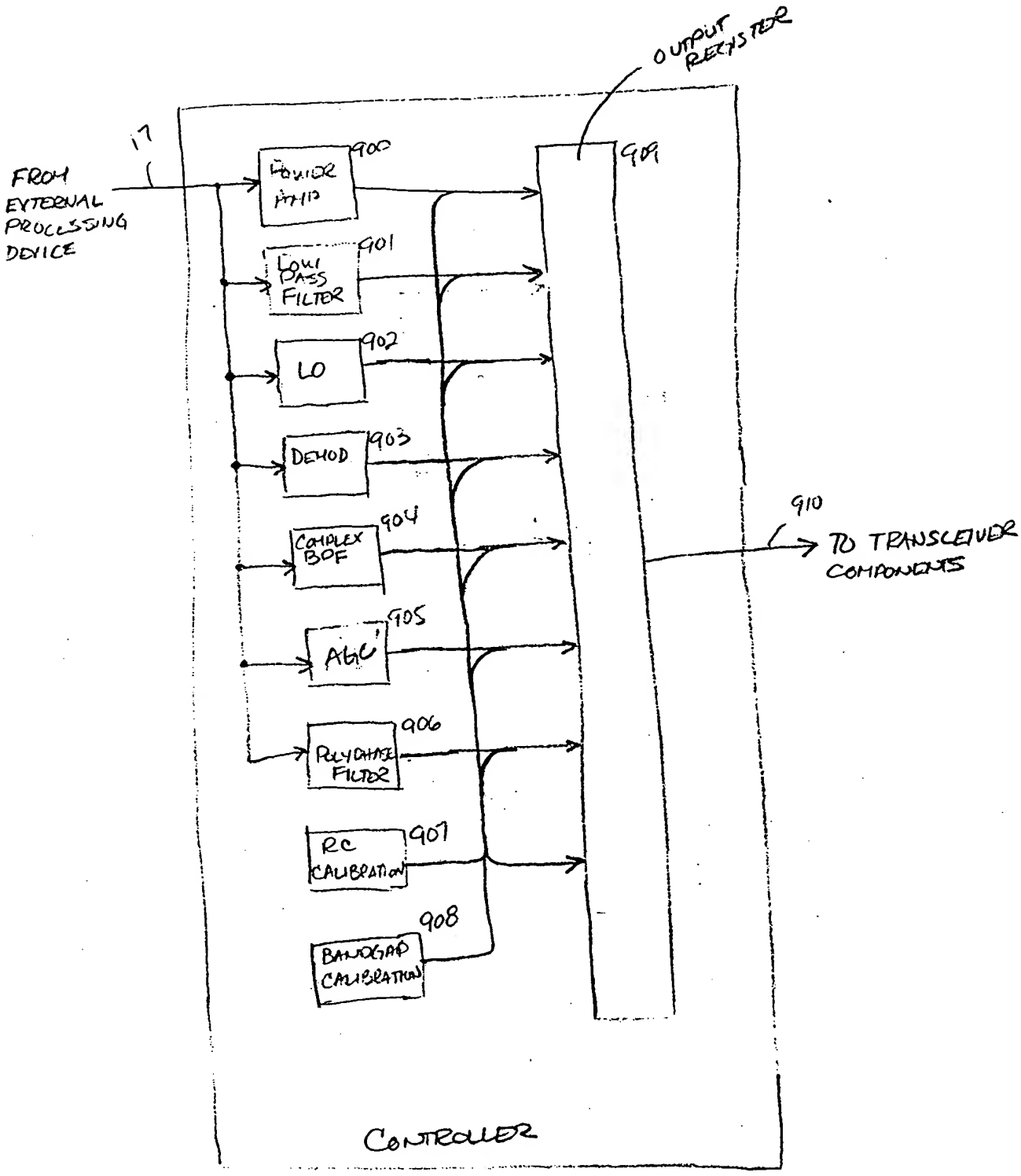

OUTPUT REGISTER
17
FROM EXTERNAL PROCESSING DEVICE
900
909
LOW PASS FILTER
901
LO
902
DEMOD
903
COMPLEX BPF
904
910
TO TRANSCEIVER COMPONENTS
AGC
905
POLYPHASE FILTER
906
RC CALIBRATION
907
908
BANDGAP CALIBRATION
CONTROLLER

FIGURE 38

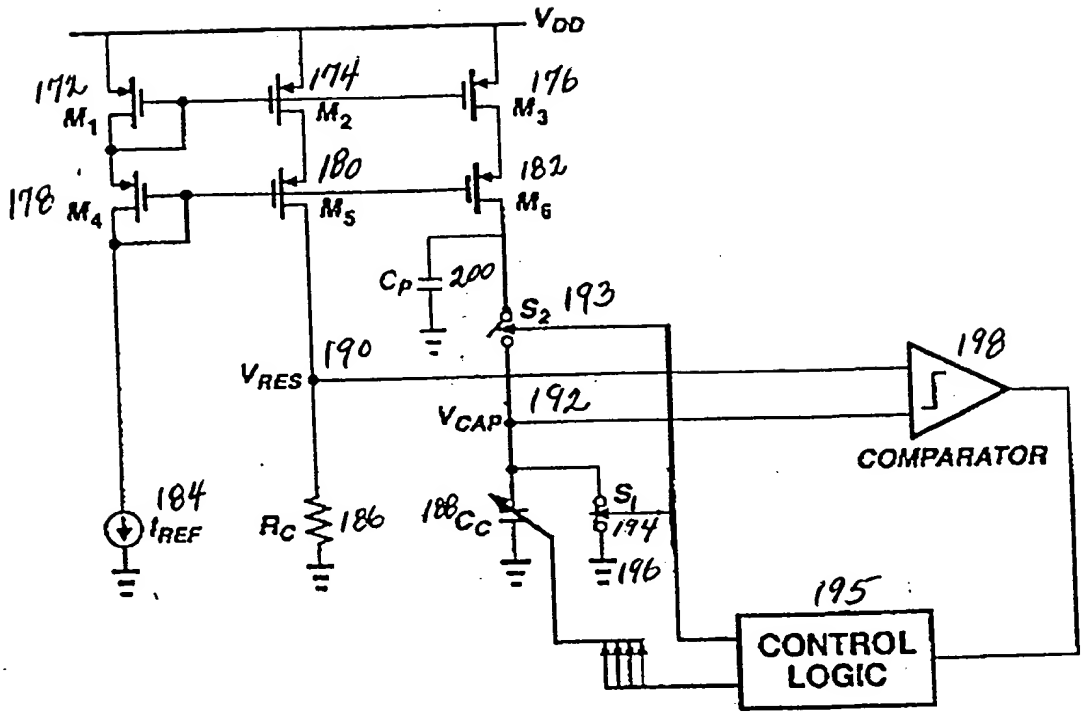

V_{DD}
172
M_1
174
M_2
176
M_3
178
M_4
180
M_5
182
M_6
C_P 200
S_2 193
190
V_{RES}
192
V_{CAP}
198
COMPARATOR
184
I_{REF}
R_C 186
188 C_C
S_1 194
196
195
CONTROL LOGIC

FIG. 39

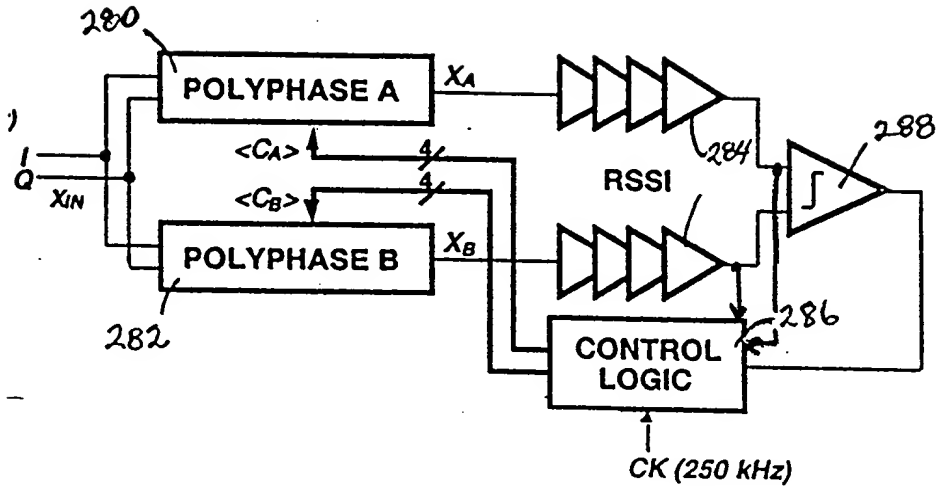

280
POLYPHASE A
X_A
I
Q
X_{IN}
$<C_A>$
4
$<C_B>$
4
RSSI
284
288
POLYPHASE B
X_B
282
286
CONTROL LOGIC
CK (250 kHz)

FIG. 40

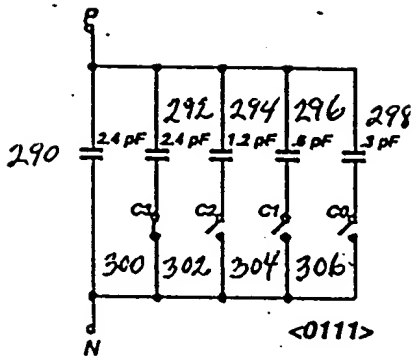

P
290
292
294
296
298
2.4 pF
2.4 pF
1.2 pF
.6 pF
.3 pF
C3
C2
C1
C0
300
302
304
306
N
<0111>

FIG. 41

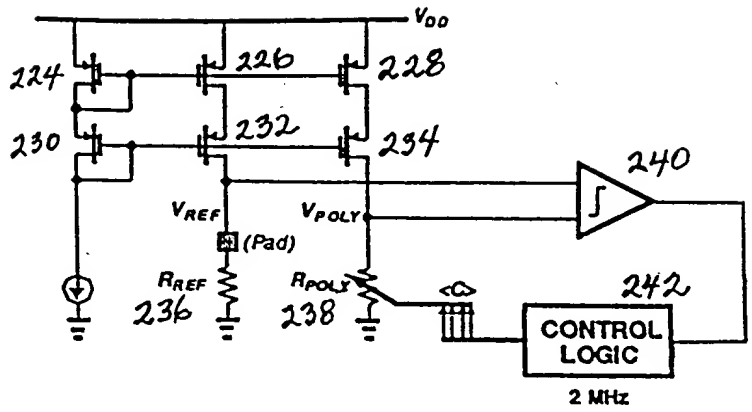

V_{DD}
224
226
228
230
232
234
240
V_{REF}
V_{POLY}
(Pad)
R_{REF}
236
R_{POLY}
238
242
CONTROL LOGIC
2 MHz

FIG. 42

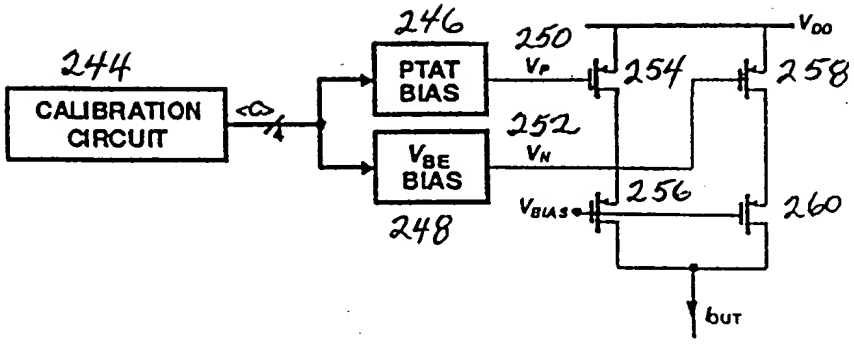

244
CALIBRATION CIRCUIT
<Q>
246
PTAT BIAS
248
V_{BE} BIAS
250
V_P
252
V_N
254
256
258
260
V_{BIAS}
V_{DD}
I_{OUT}

FIG. 43

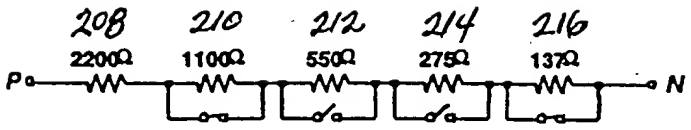


FIG. 44

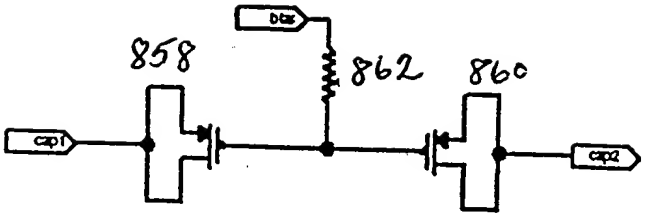


FIG. 45

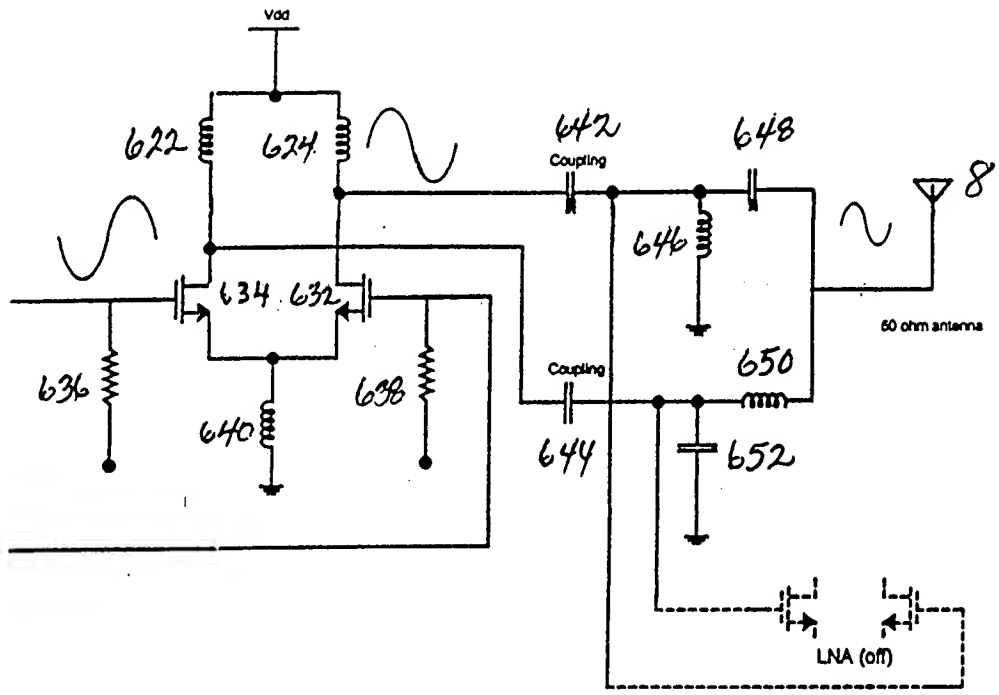


FIG. 46

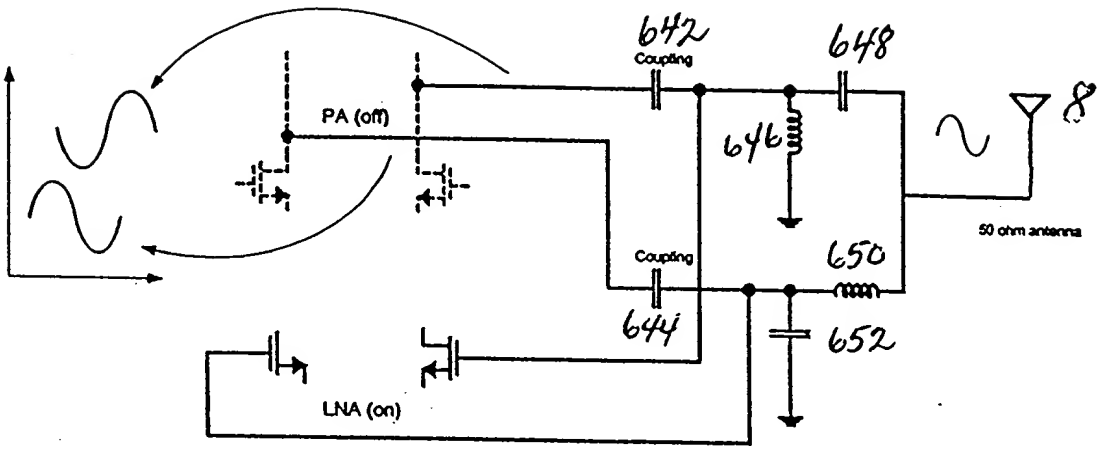

642
Coupling
648
PA (off)
646
8
50 ohm antenna
Coupling
650
644
652
LNA (on)

FIG. 47

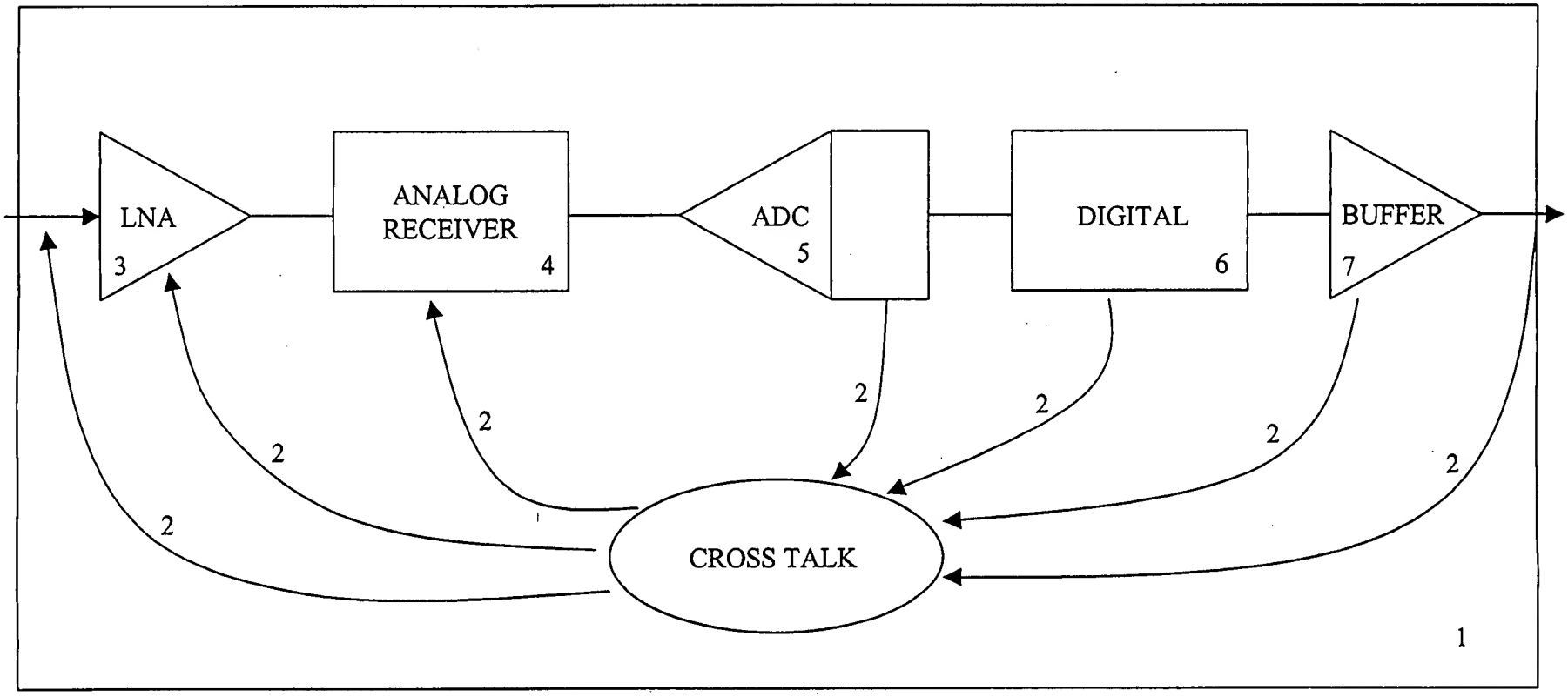


FIG. 4a

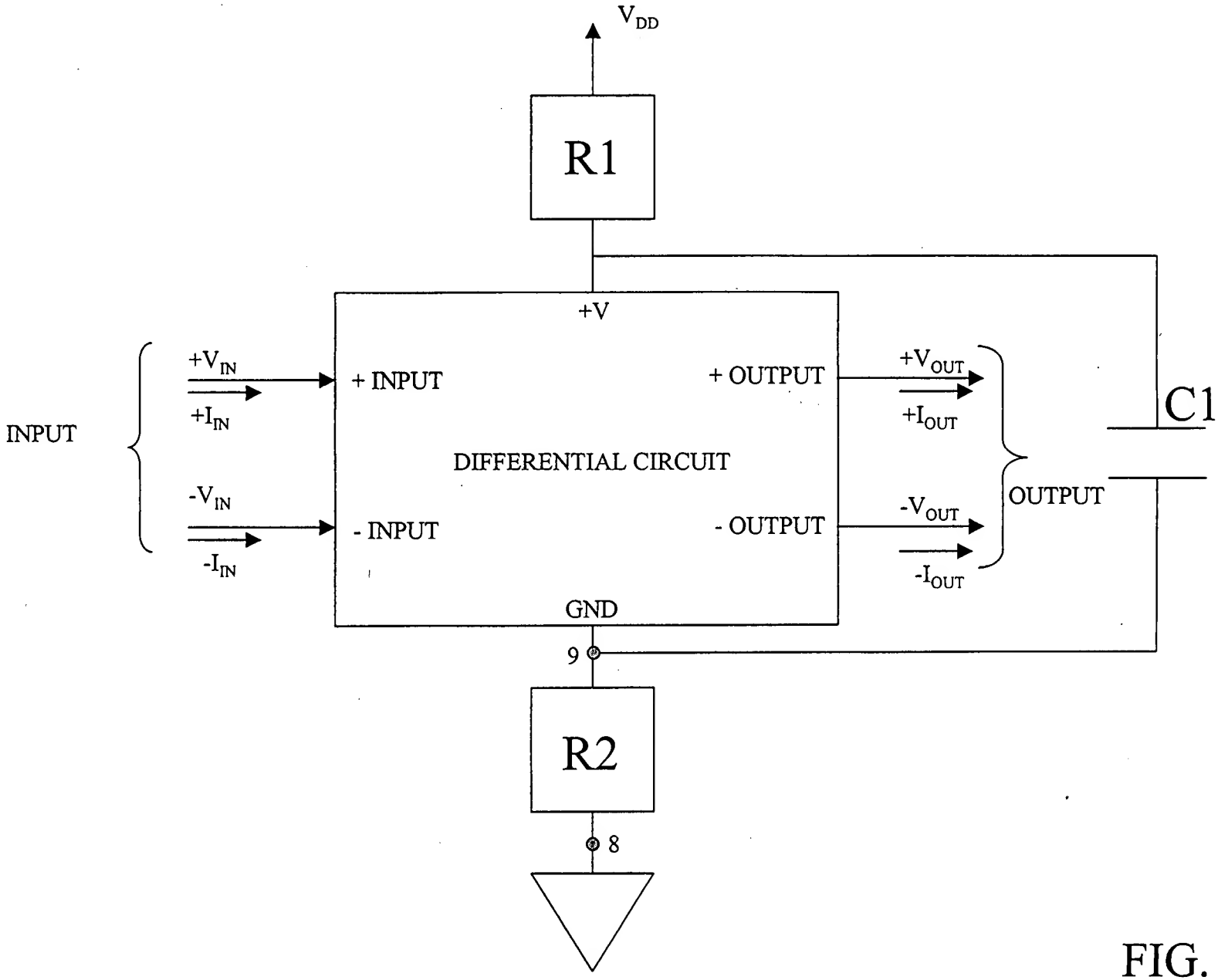

V_{DD}
R1
+V
INPUT
$+V_{IN}$
$+I_{IN}$
+ INPUT
+ OUTPUT
$+V_{OUT}$
$+I_{OUT}$
C1
DIFFERENTIAL CIRCUIT
$-V_{IN}$
$-I_{IN}$
- INPUT
- OUTPUT
$-V_{OUT}$
$-I_{OUT}$
OUTPUT
GND
9
R2
8

FIG. 406

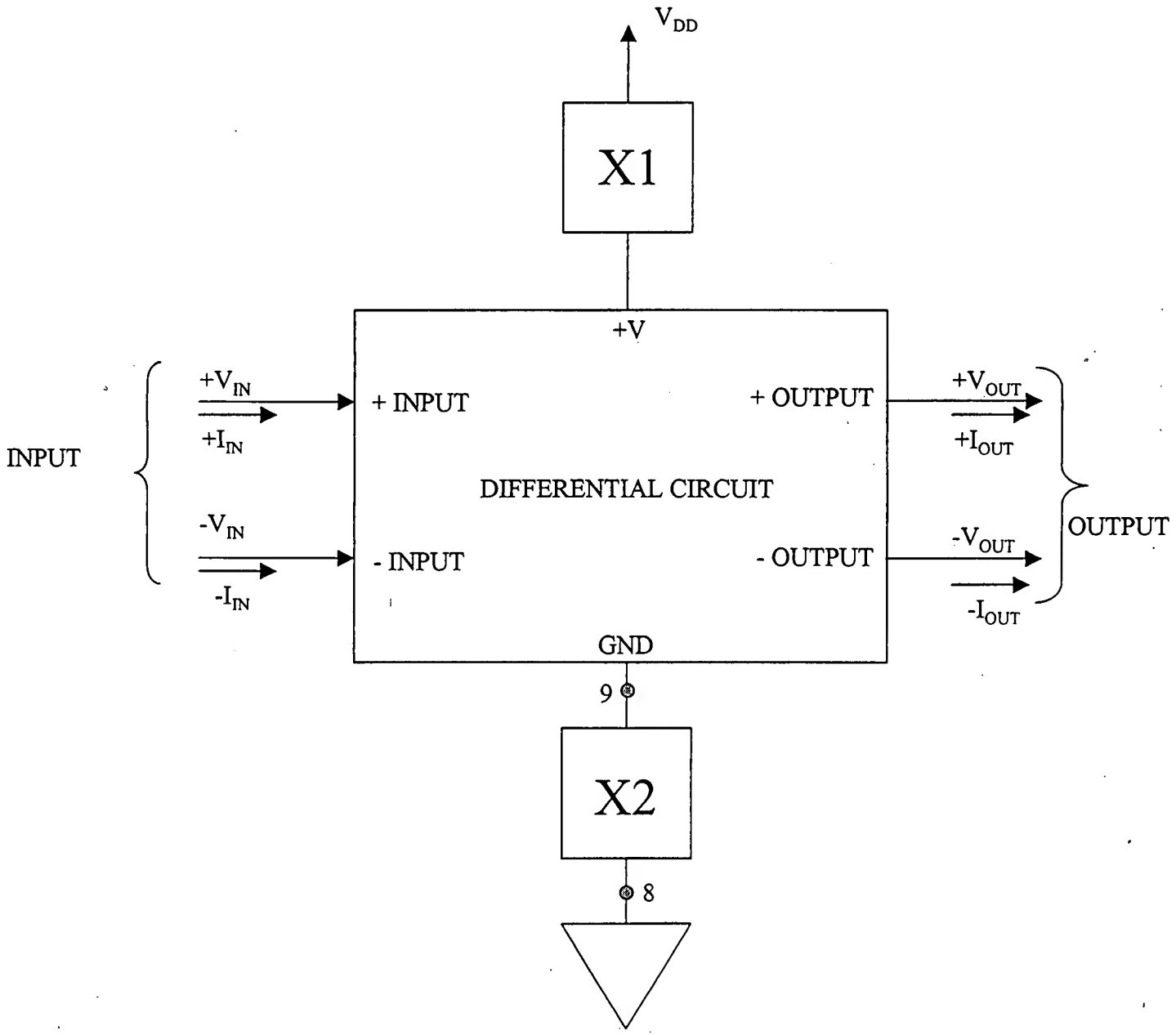

V_{DD}
X1
+V
INPUT
$+V_{IN}$
$+I_{IN}$
+ INPUT
+ OUTPUT
$+V_{OUT}$
$+I_{OUT}$
DIFFERENTIAL CIRCUIT
$-V_{IN}$
$-I_{IN}$
- INPUT
- OUTPUT
$-V_{OUT}$
$-I_{OUT}$
OUTPUT
GND
9
X2
8

FIG. 48c

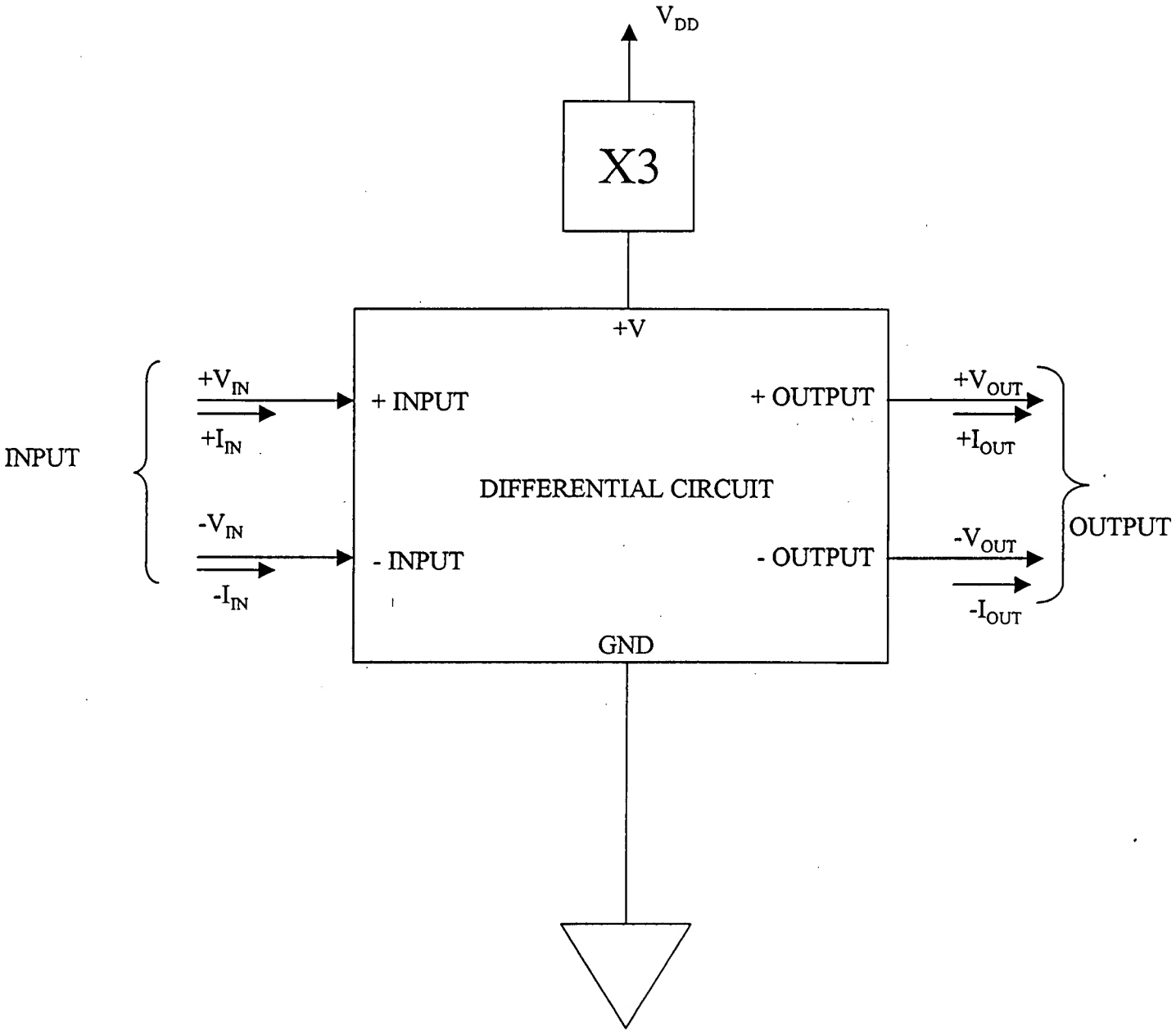


FIG. 48d

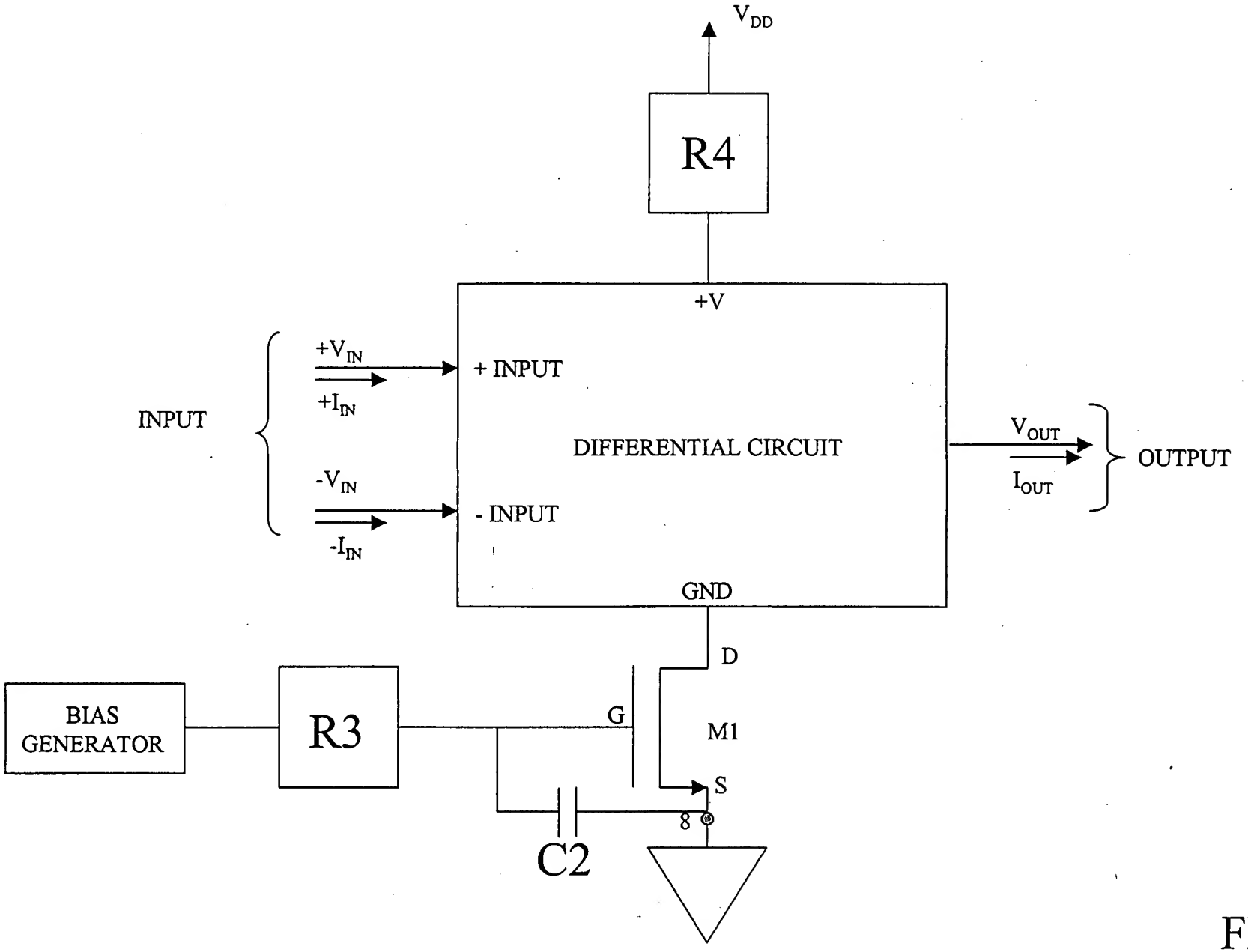

V_{DD}
R4
+V
$+V_{IN}$
$+I_{IN}$
+ INPUT
INPUT
DIFFERENTIAL CIRCUIT
V_{OUT}
I_{OUT}
OUTPUT
$-V_{IN}$
$-I_{IN}$
- INPUT
GND
D
BIAS GENERATOR
R3
G
M1
S
C2

FIG. 48e

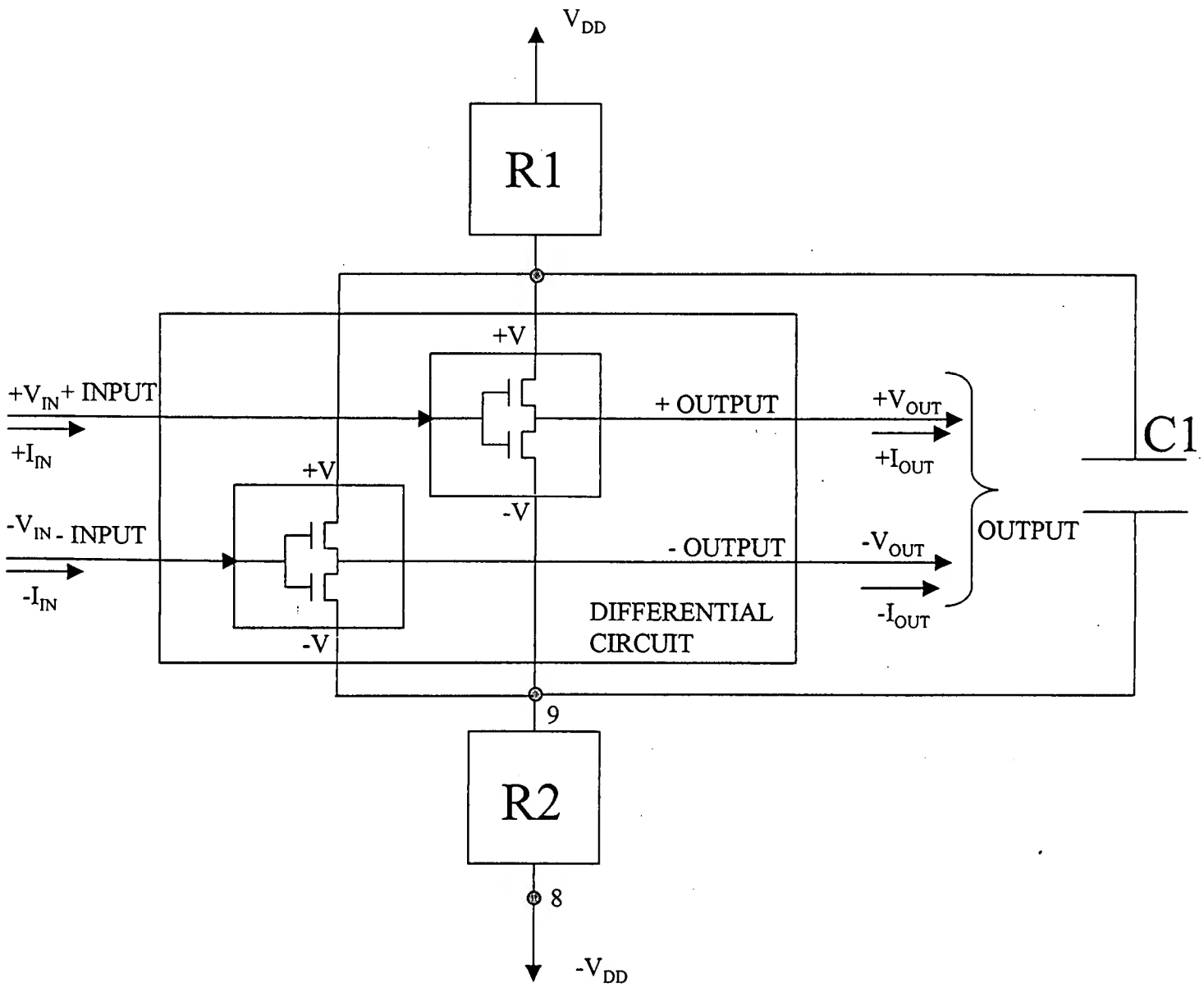

V_{DD}
R1
+V
$+V_{IN}$+ INPUT
$+I_{IN}$
+ OUTPUT
$+V_{OUT}$
$+I_{OUT}$
C1
+V
-V
$-V_{IN}$ - INPUT
$-I_{IN}$
- OUTPUT
$-V_{OUT}$
$-I_{OUT}$
OUTPUT
-V
DIFFERENTIAL
CIRCUIT
9
R2
8
$-V_{DD}$

FIG. 48f